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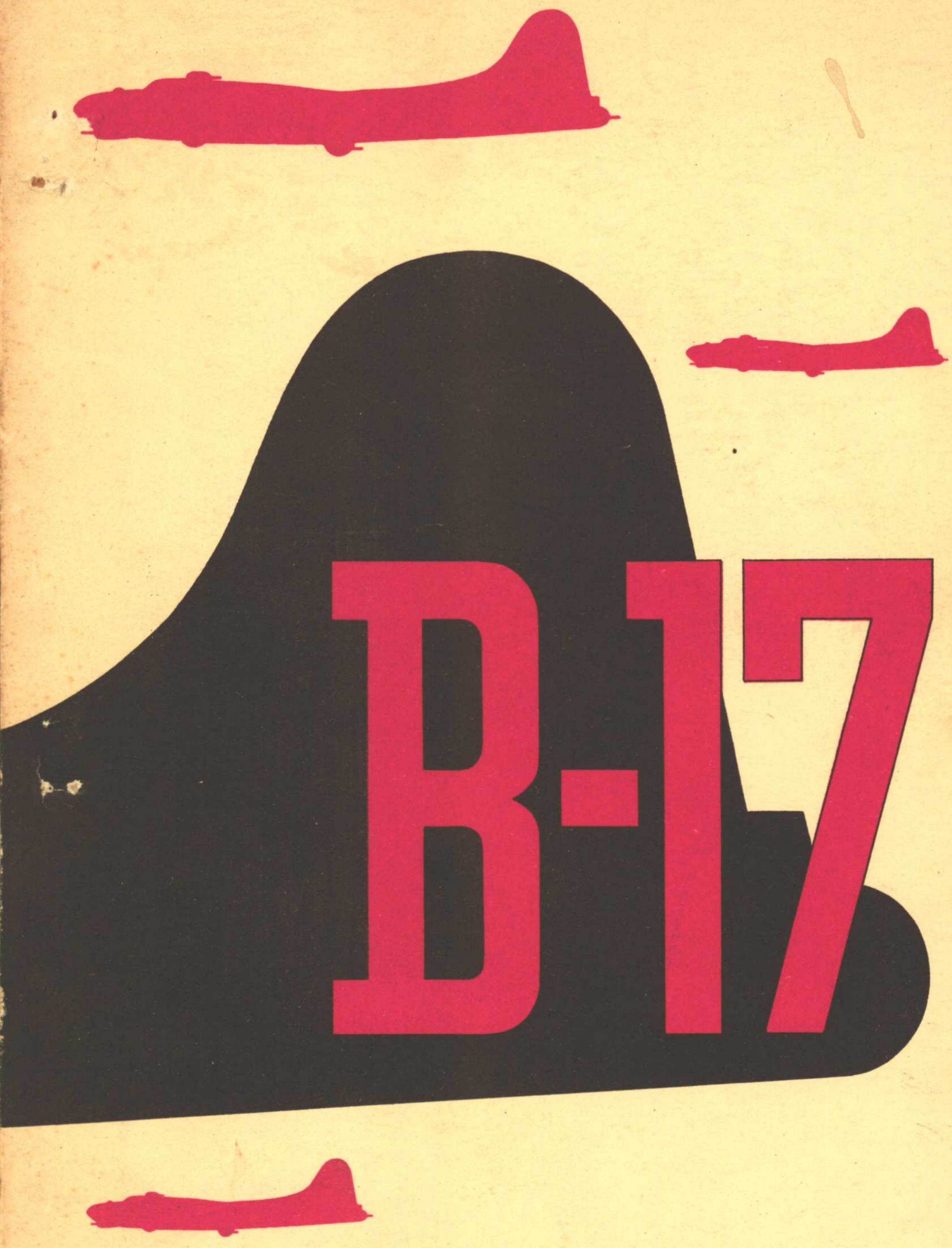

B-17

THIS REVISED EDITION SUPERSEDES THE ORIGINAL (GRAY COVERED) PILOT TRAINING MANUAL FOR THE FLYING FORTRESS. ALL COPIES OF THE LATTER ARE RESCINDED.

Revised 1 May, 1945

AAF Manual No. 50-13

PILOT TRAINING MANUAL FOR THE FLYING FORTRESS

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B-17

REVISED 1 MAY, 1945

PUBLISHED FOR HEADQUARTERS, AAF, OFFICE OF ASSISTANT CHIEF OF AIR STAFF TRAINING BY HEADQUARTERS, AAF, OFFICE OF FLYING SAFETY

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U.S.

Foreword

THIS MANUAL is the text for your training as a B-17 pilot and airplane commander.

The Air Forces' most experienced training and supervisory personnel have collaborated to make it a complete exposition of what your pilot duties are, how each duty will be performed, and why it must be performed in the manner prescribed.

The techniques and procedures described in this book are standard and mandatory. In this respect the manual serves the dual purpose of a training checklist and a working handbook. Use it to make sure that you learn everything described herein. Use it to study and review the essential facts concerning everything taught. Such additional self-study and review will not only advance your training, but will alleviate the burden of your already overburdened instructors.

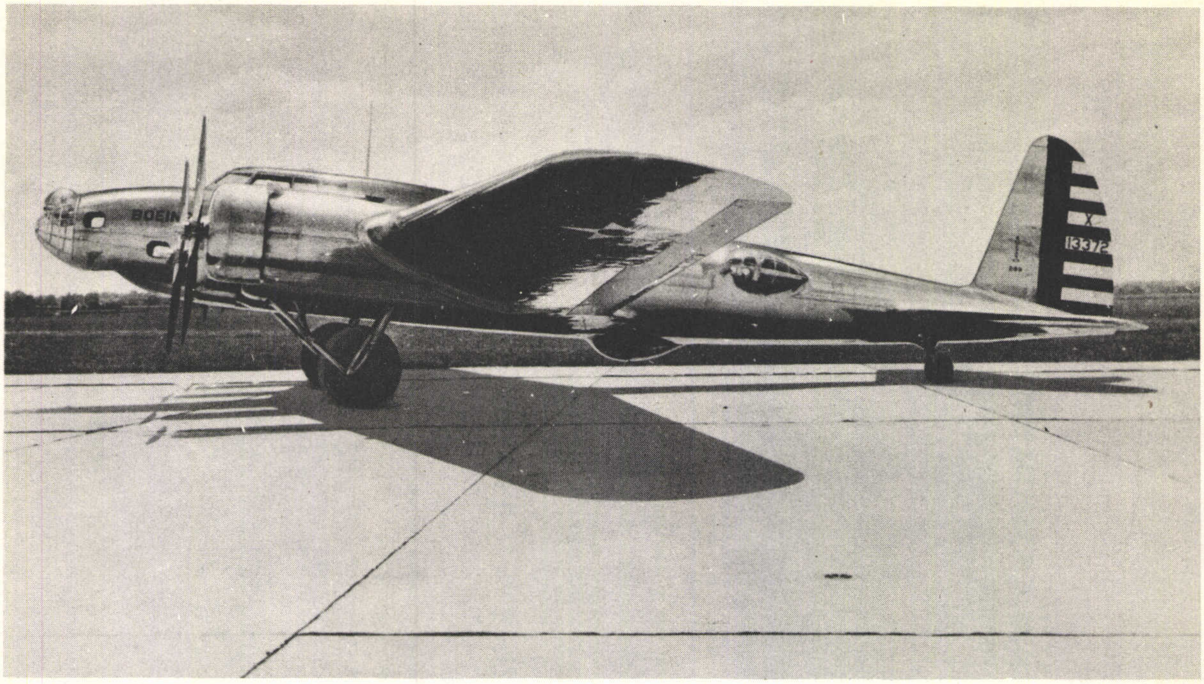
This training manual does not replace the Technical Orders for the airplane, which will always be your primary source of information concerning the B-17 so long as you fly it. This is essentially the textbook of the B-17. Used properly, it will enable you to utilize the pertinent Technical Orders to even greater advantage.

H H Arnold

COMMANDING GENERAL, ARMY AIR FORCES

Additional copies of this manual should be requested from:

HEADQUARTERS AAF, OFFICE OF FLYING SAFETY, SAFETY EDUCATION DIVISION, Winston-Salem 1, North Carolina.



THE FIRST FORTRESS: The Air Corps called for a "battleship of the skies;" Boeing offered the "299" (later the XB-17); observers called it a "regular fortress with wings." It exceeded expectations, later crashed—victim of pilot error.

THE STORY OF THE B-17

In 1934 the U. S. Army Air Corps asked for a battleship of the skies. The specifications called for a "multi-engine" bomber that would have a high speed of 200-250 mph at 10,000 feet, an operating speed of 170-200 mph at the same altitude, a range of 6 to 10 hours, and a service ceiling of 20,000-25,000 feet.

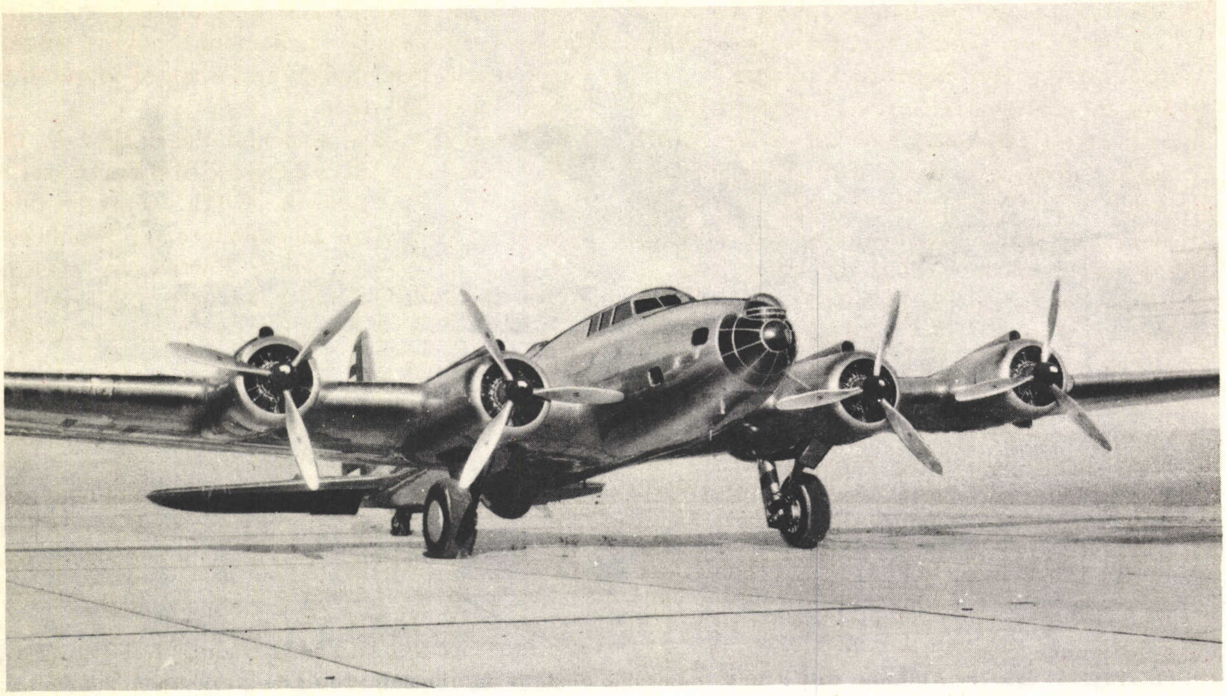
Boeing designers figured that with a conventional 2-engine type of airplane they could meet all specifications and probably better them. But such a design probably would not provide much edge over the entries of competitors. They decided to build a revolutionary type of 4-engine bomber.

In July 1935 an airplane such as the world had never seen before rolled out on the apron of the Boeing plant at Seattle, Wash. It was huge: 105 feet in wing span, 70 feet from nose to tail, 15 feet in height, It was equipped with 4 Pratt & Whitney Hornet 750 Hp engines, and 4 Hamilton Standard 3-bladed constant-speed propellers. To eliminate air resistance, its bomb load was tucked away in internal bomb bays. Pilots and crew had soundproofed, heated, comfortable quarters where they could operate efficiently while flying in any kind of climate. And the big bomber bristled with formidable firepower.

"It's a regular fortress," someone observed, "a fortress with wings."

Thus the Boeing 299, later designated the XB-17, was born—the grandfather of the Flying Fortress that was to become champion and pace-setter of all heavy bombardment aircraft in the World War II.

The XB-17 surpassed all Army specifications



NEXT CAME THE Y1B-17: Thirteen were delivered in 1937. One stalled, spun down over Langley Field, recovered, landed safely. Recording instruments showed it had held up under greater stress than it was designed to stand.

THE B-17A WENT HIGHER: Equipped with turbos, it topped all previous service ceilings, gave maximum performance above 30,000 ft. To range, speed, bomb load, firepower, the B-17 added another advantage: altitude operation.

for speed, climb, range, and load-carrying requirements. Then, in October, 1935, it crashed at Wright Field when a test pilot neglected to unlock the elevator controls on takeoff.

But the Army Air Corps recognized in this first Fortress the heavy bomber of the future. Thirteen airplanes, designated Y1B-17, were ordered. While one airplane was held at Wright Field for experimental purposes, the other 12 went out to set new range and speed records, cruising the Western Hemisphere, and confounding skeptics who said that the Flying Fortress was "too much airplane for any but super-pilots." Not one of the 12 was ever destroyed by accident.

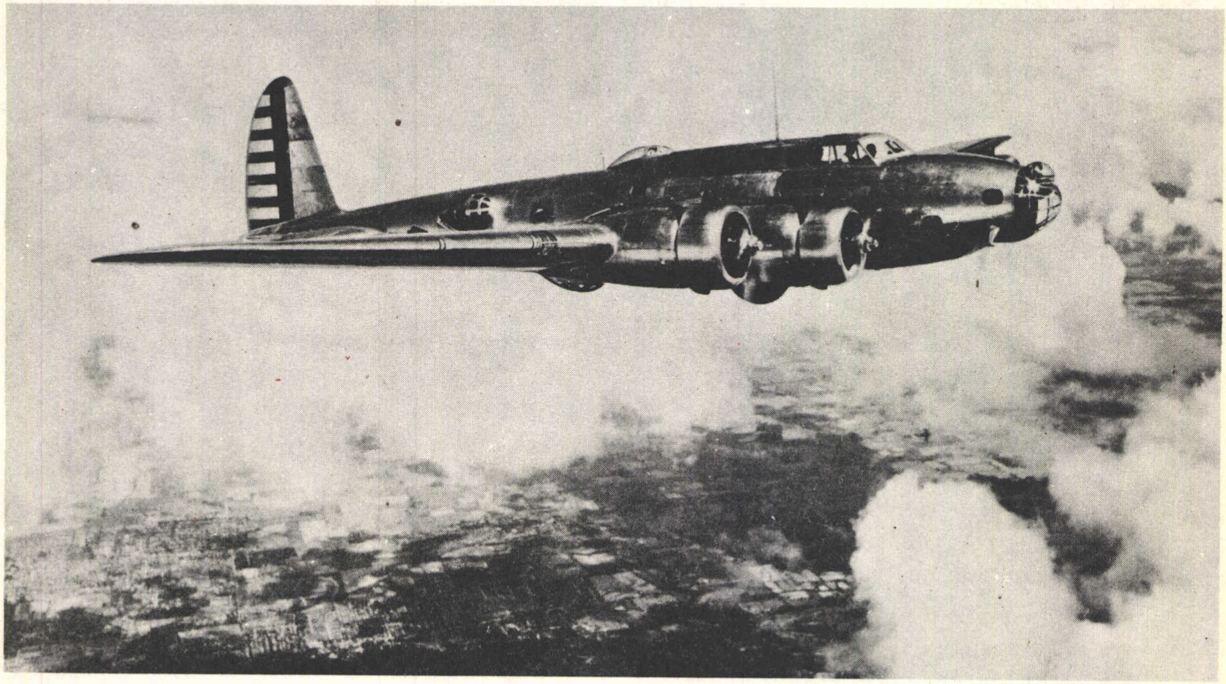
With experience, the Fortress acquired new strength, virtues, possibilities. The Y1B-17A, equipped with Wright G Cyclone engines and General Electric turbo-superchargers, gave astonishing performances at altitudes above 30,000 feet. The B-17B, flight tested in 1939, had 1000 Hp Wright Cyclone engines and hydromatic full-feathering propellers.

In the spring of 1940, when Hitler had overrun Norway, Denmark, Holland, Belgium, and France, the B-17C made its debut with more armor plate for crew protection, more power in its engines. The B-17D took on leakproof fuel tanks, increased armament, better engine cooling in fast climbs, and a speed increase to more than 300 mph.

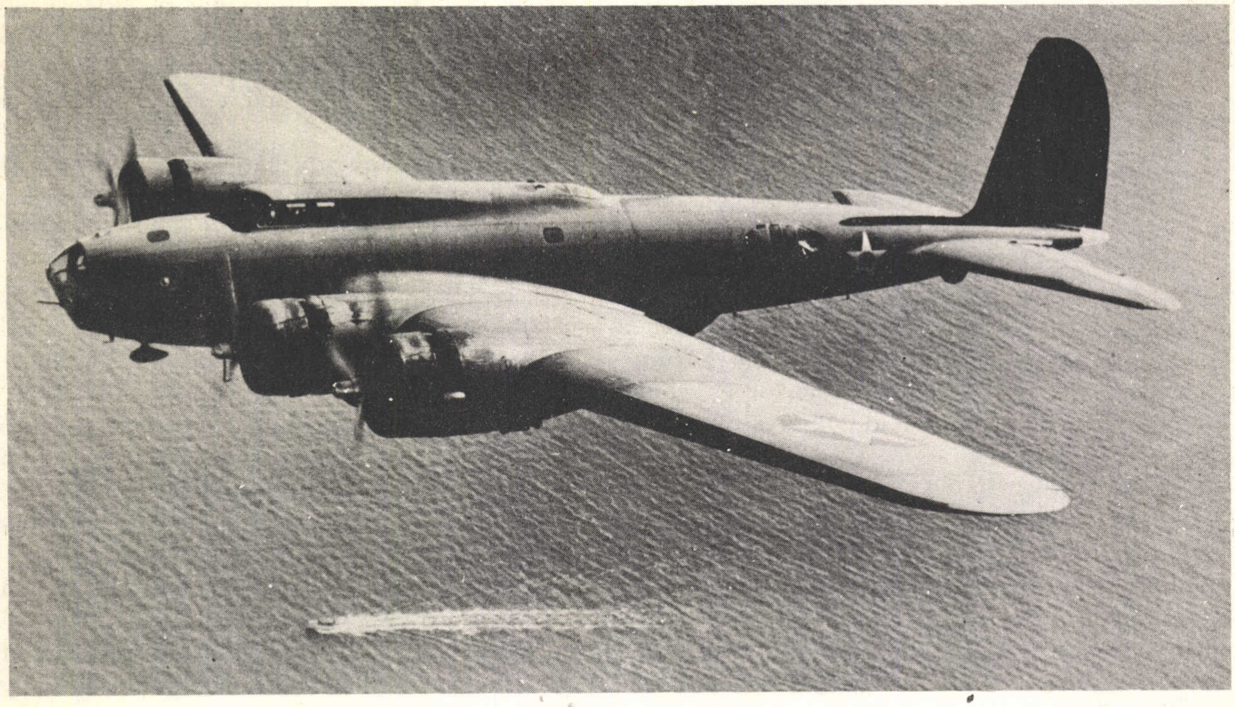
When the Japs attacked Pearl Harbor, the B-17C's and B-17D's were the first Fortresses to see action. But soon the B-17E's were on their way to join them in even greater numbers—faster, heavier, sturdier Fortresses, packing .50-cal. waist and tail guns, with a Sperry ball turret under the fuselage, and another power turret on top.

By the spring of 1942, still another Fortress—the B-17F—with longer range, greater bomb load capacity, more protective armament and striking power, was streaking across both Atlantic and Pacific in enormous numbers to provide what General Arnold called "the guts and backbone of our world-wide aerial offensive."

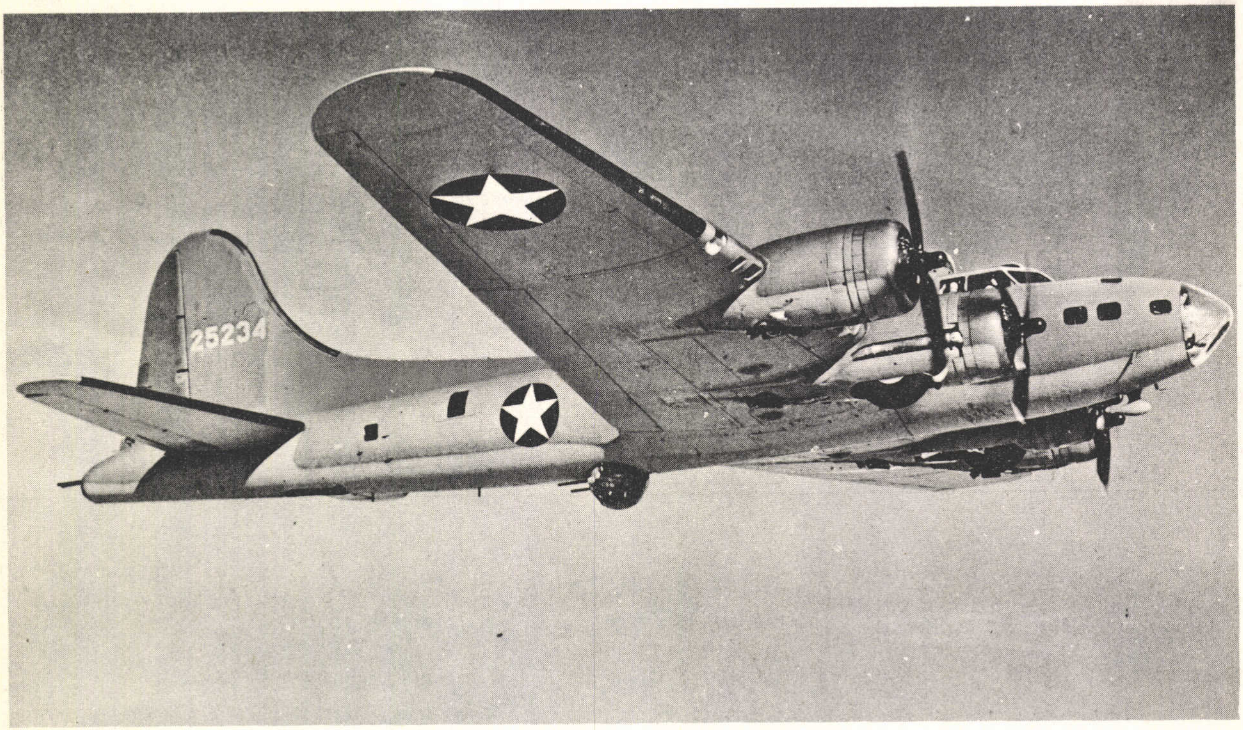
The new B-17G, seventh major revision of the Flying Fortress, is now in operation at many bases in the continental United States. It incorporates a number of new features which have been developed as a result of the B-17's extensive combat experience.



THE FIRST B-17B left Seattle 1 August, 1939, arrived in New York 9 hours, 14 minutes later, setting a new coast-to-coast non-stop record. Later, seven B-17B's cruised the hemisphere for the 50th anniversary of the Republic of Brazil



THE B-17D SAW ACTION FIRST: When the Japs struck, Fortresses of the C and D series gained experience that later made the B-17 the "guts and backbone of our worldwide aerial offensive." B-17E was first wartime model.



THE B-17F FULFILLED THE PROMISE: With over 400 major changes—producing greater speed, range, bomb load, firepower, crew protection—new Forts swept the Pacific and the heart of Europe, raised the curtain on D-Day.

Rugged Forts Make History

The combat record of the Flying Fortress has been written daily in newspaper headlines since Dec. 7, 1941.

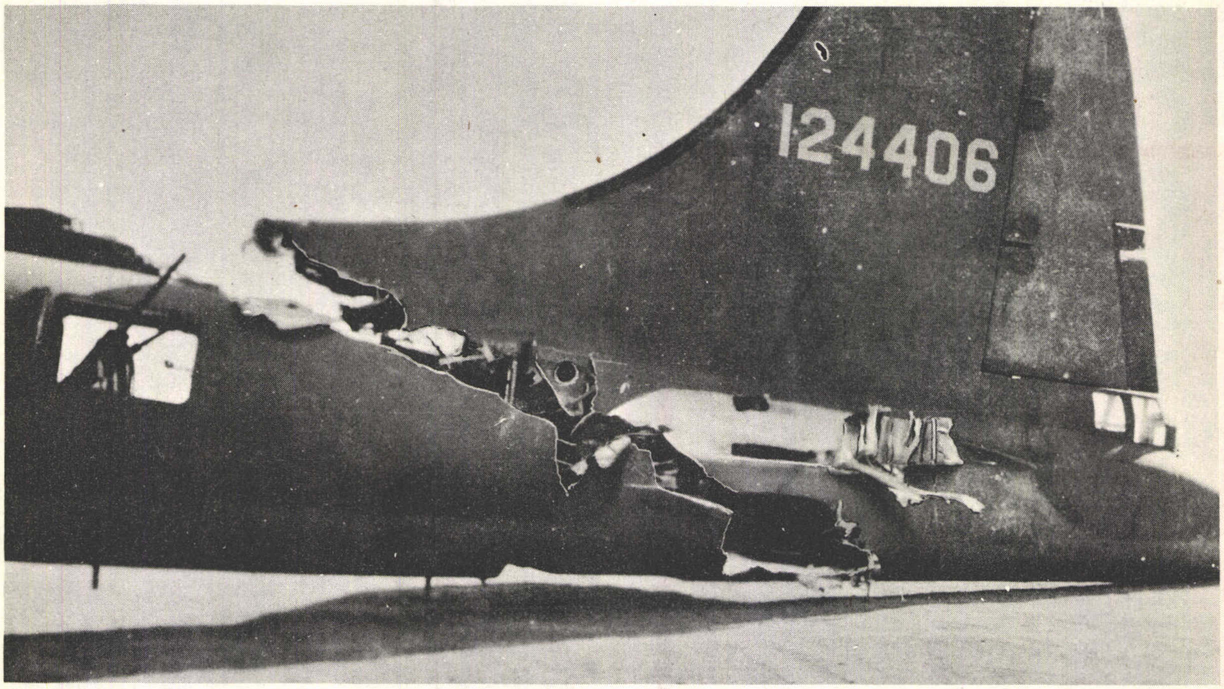
From the hour of Pearl Harbor, through the dark, early months of the war in the Pacific, they were sinking Jap ships and shooting arrogant Zeros out of the skies.

They carried the war to the enemy in the Coral Sea, over Guadalcanal, New Guinea, Java, Burma, and the Bismarck Sea.

Changing tactics, they hedgehopped volcanic peaks, flew practically at water level through unbroken fog, to bomb the Japs out of the Aleutians.

They flew the blistering deserts to drive the enemy out of North Africa, the Mediterranean, Sicily, and open the way to Rome.

Pilot points proudly to battle-scarred Fortress—calls it "series of holes held together by ragged metal."



Doomed ME 109 plowed into this Flying Fortress over Tunisia, cutting fuselage nearly in half, entirely removing one elevator. Pilot nursed the airplane home to British base, brought it in for a perfect landing.

Beginning in August, 1942, they brought daylight bombing to Hitler's Europe, first over strategic targets in Occupied France, then gradually spreading out over the continent until, in the spring of 1944, shuttle bombing from bases in Britain and Russia left no corner of the once haughty Festung Europa safe from concentrated Allied bombing attacks.

Switching for the moment from strategic to tactical missions, they helped seal off the Normandy peninsula from effective enemy counterattack and make the miracle of D-Day possible. They blasted a path out of the narrow beachheads for the hard-hitting ground forces to crash their way through into Hitler's inner fortress. Then back again to their relentless job of crushing German war industry.

Detailed Fortress history must remain a voluminous post-war job for military historians. For pilots, however, one important fact stands clear-cut now. The Flying Fortress is a rugged airplane.

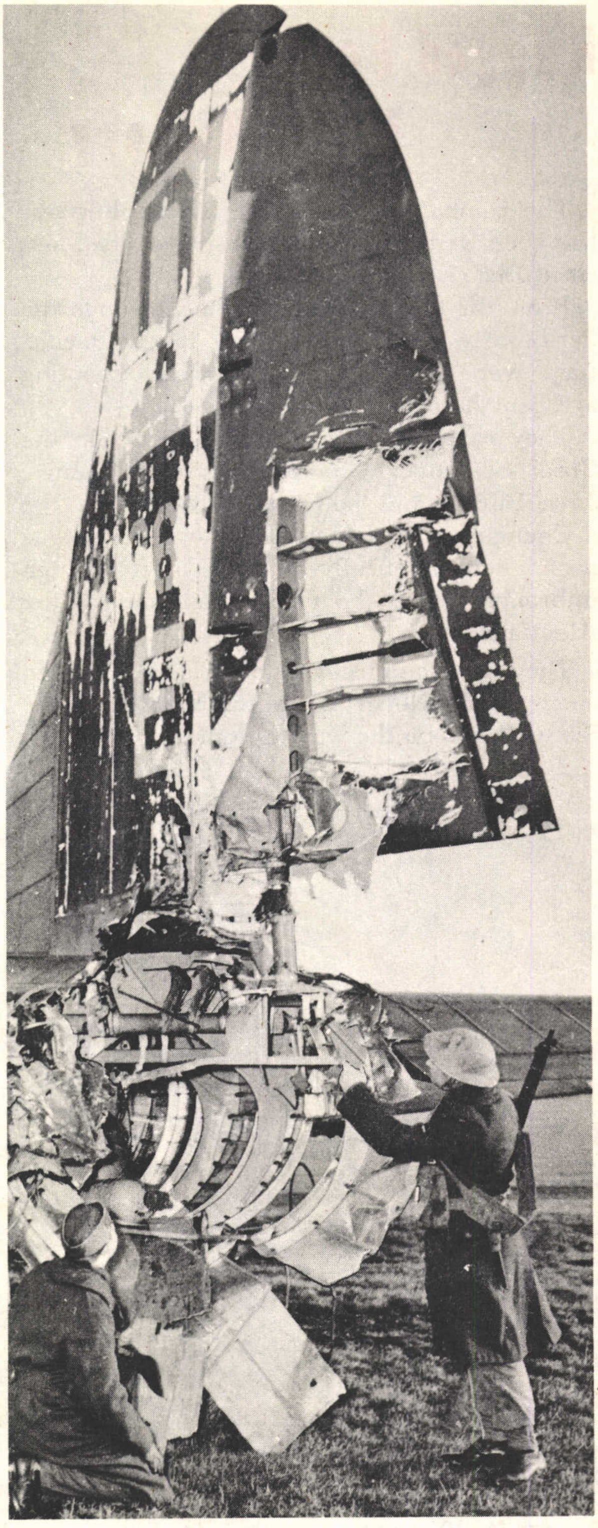
In the words of one veteran: "She'll not only get you to the target and do the job, but she'll fight her way out, take terrific punishment, and get you safely home."

Headlines have reiterated that fact with heart-warming redundancy:

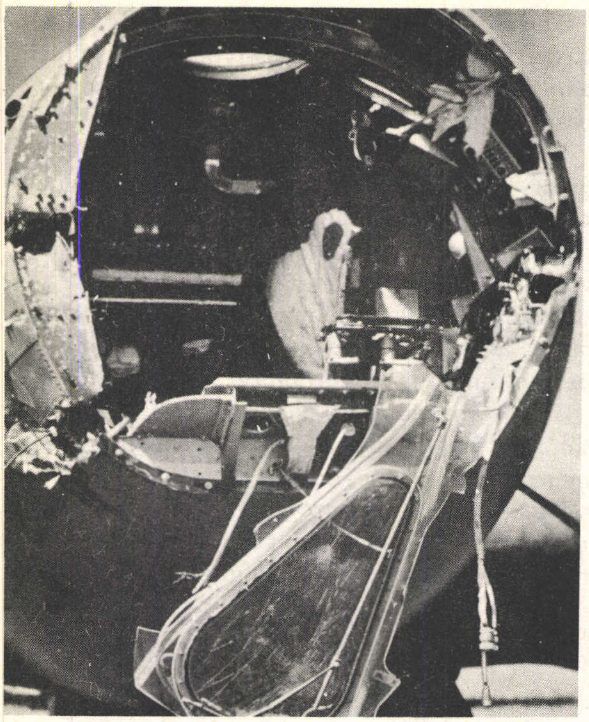
The ground crew looked up and saw, coming down for a landing, not the Flying Fortress, but a lone motor. Sitting on the motor was a sergeant with a machine gun across his lap. He brought the motor down to a beautiful no-point landing, jumped off.

"Boy," he said, "were we in a fight!"

—*Yank: The Army Weekly*

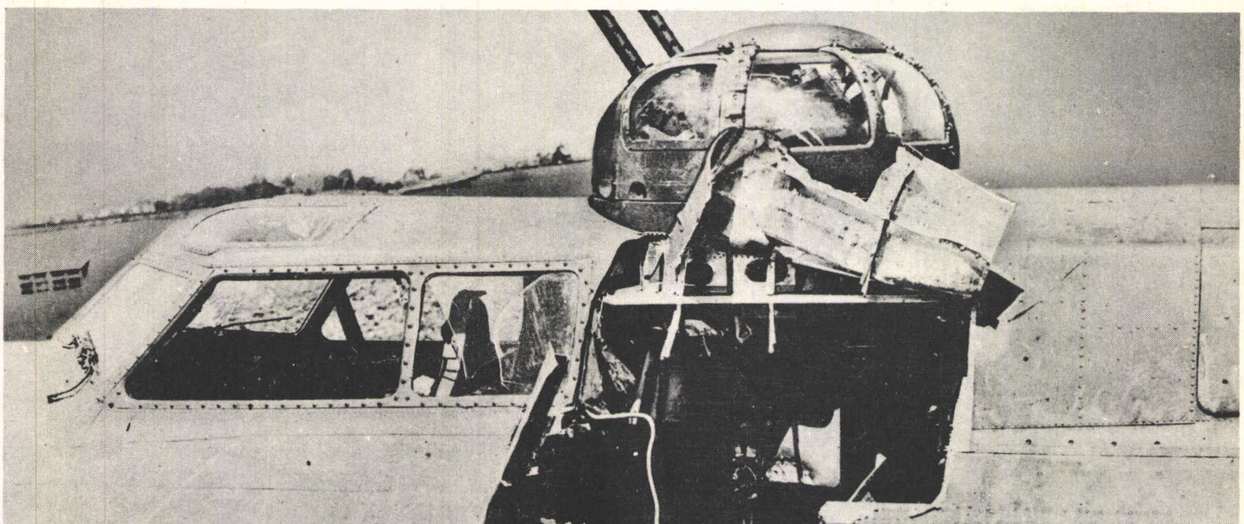


With only ragged pieces of tail left, this Fortress, believed wrecked in enemy territory, limped home.



Swarms of FW 190's shot out plexiglas nose, killed navigator, wounded entire crew. Pilot brought in airplane safely despite loss of flaps, hydraulic system.

Gaping flak and shell holes, received while bombing Nazi aircraft factories, failed to prevent "F for Frenesi" from returning safely with three wounded gunners.



Fragments of German 8.3-inch rocket tore into fuselage aft of cockpit, made long journey home difficult. Most Fortress crews, always amazed by airplane's ability to take it, have a word for the fighting B-17: "Rugged."

40 NAZIS RIDDLE FORT, BUT FAIL TO DOWN IT.

LAME FORTRESS BAGS 6 GERMANS, MAKES HOME BASE.

FORT FALLS 10,000 FEET, BUT COMPLETES RAID.

HARD-HIT FORT CUTS LOOSE BALL TURRET, GETS HOME.

B-17, SPLIT IN TWO, LANDS SAFELY.

FORT LIMPS HOME ON ONE MOTOR.

The B-17's incredible capacity to take it—to come flying home on three, two, even one engine, sieve-like with flak and bullet holes, with large sections of wing or tail surfaces shot away—has been so widely publicized that U. S. fighting men could afford to joke about it.

But the fact remains: the rugged Forts can take it and still fly home. Why?

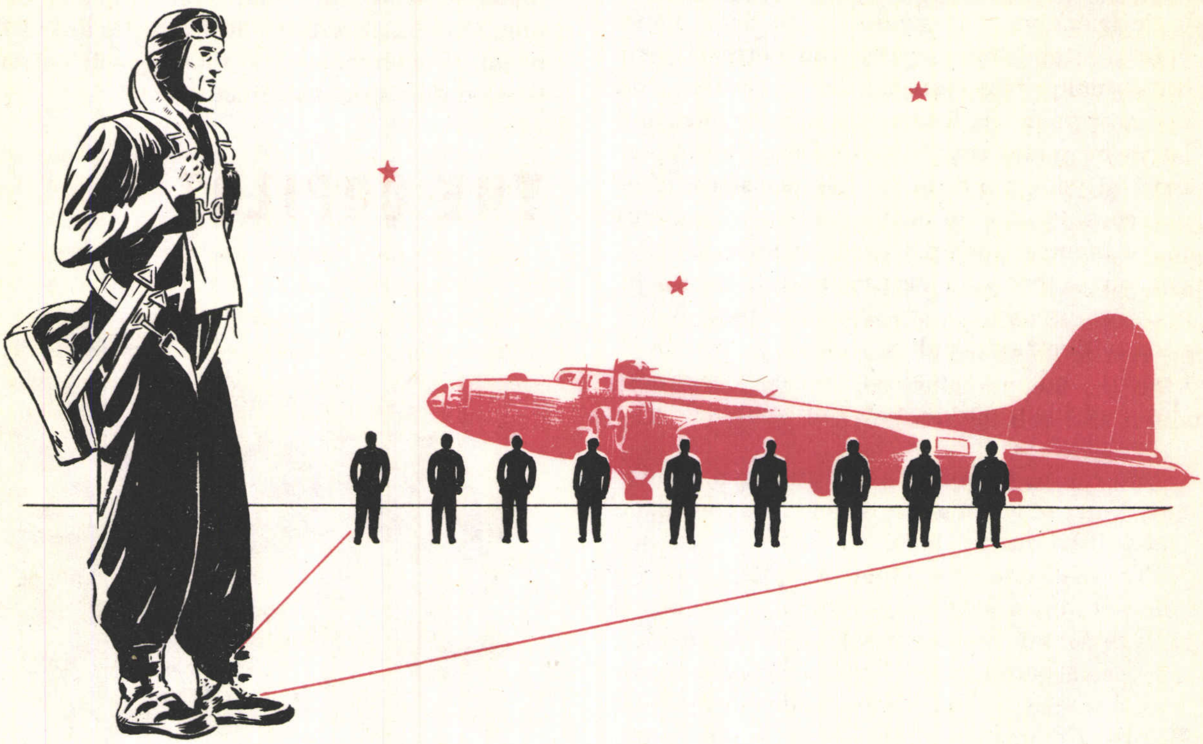
The B-17 is built for battle. Its wings are constructed with heavy truss-type spars which tend to localize damage by enemy fire so that basic wing strength is not affected.

Because of its unusual tail design, the airplane can be flown successfully even when vertical or horizontal tail surfaces have been partially destroyed, or with one or more engines shot away.

Even when battle damage prevents use of all other control methods, the autopilot provides near-normal maneuverability.

There are many other reasons. But perhaps the most important of all is the fact that every man who flies one knows that the B-17 is a pilot's airplane. It inspires confidence and warrants it. For the fulfillment of its intended function it demands just one thing: pilot know-how.

DUTIES AND RESPONSIBILITIES OF THE AIRPLANE COMMANDER



Your assignment to the B-17 airplane means that you are no longer just a pilot. You are now an airplane commander, charged with all the duties and responsibilities of a command post.

You are now flying a 10-man weapon. It is your airplane, and your crew. You are responsible for the safety and efficiency of the crew at all times—not just when you are flying and fighting, but for the full 24 hours of every day while you are in command.

Your crew is made up of specialists. Each man—whether he is the navigator, bombardier, engineer, radio operator, or one of the gunners—is an expert in his line. But how well he does his job, and how efficiently he plays his part as a member of your combat team, will depend to a great extent on how well you play your own part as the airplane commander.

Get to know each member of your crew as an individual. Know his personal idiosyncrasies, his capabilities, his shortcomings. Take a personal interest in his problems, his ambitions, his need for specific training.

See that your men are properly quartered, clothed, and fed. There will be many times, when your airplane and crew are away from the home base, when you may even have to carry your interest to the extent of financing them yourself. Remember always that you are the commanding officer of a miniature army—a specialized army; and that morale is one of the biggest problems for the commander of any army, large or small.

Crew Discipline

Your success as the airplane commander will depend in a large measure on the respect, confidence, and trust which the crew feels for you. It will depend also on how well you maintain crew discipline.

Your position commands obedience and respect. This does not mean that you have to be stiff-necked, overbearing, or aloof. Such characteristics most certainly will defeat your purpose.

Be friendly, understanding, but firm. Know your job; and, by the way you perform your duties daily, impress upon the crew that you do know your job. Keep close to your men, and let them realize that their interests are uppermost in your mind. Make fair decisions, after due consideration of all the facts involved; but make them in such a way as to impress upon your crew that your decisions are to stick.

Crew discipline is vitally important, but it need not be as difficult a problem as it sounds. Good discipline in an air crew breeds comradeship and high morale, and the combination is unbeatable.

You can be a good CO, and still be a regular guy. You can command respect from your men, and still be one of them.

"To associate discipline with informality, comradeship, a leveling of rank, and at times a shift in actual command away from the leader, may seem paradoxical," says a brigadier general, formerly a Group commander in the VIII Bomber Command. "Certainly, it isn't down the military groove. But it is discipline just the same—and the kind of discipline that brings success in the air."

Crew Training

Train your crew as a team. Keep abreast of their training. It won't be possible for you to follow each man's courses of instruction, but you can keep a close check on his record and progress.

Get to know each man's duties and problems. Know his job, and try to devise ways and means of helping him to perform it more efficiently.

Each crew member naturally feels great pride in the importance of his particular specialty. You can help him to develop his pride to include the manner in which he performs that duty. To do that you must possess and maintain a thorough knowledge of each man's job and the problems he has to deal with in the performance of his duties.

Brief your entire crew on every flight: the purpose of the flight, the conditions that may be encountered, and the part each crew member must play for the successful completion of the mission. Make sure that every man is thoroughly familiar with what his duties are in the event of emergencies, so that he will perform these duties almost instinctively.

THE COPILOT

The copilot is the executive officer—your chief assistant, understudy, and strong right arm. He must be familiar enough with every one of your duties—both as pilot and as airplane commander—to be able to take over and act in your place at any time.

He must be able to fly the airplane under all conditions as well as you would fly it yourself.

He must be extremely proficient in engine operation, and know instinctively what to do to keep the airplane flying smoothly even though he is not handling the controls.

He must have a thorough knowledge of cruising control data, and know how to apply it at the proper time.

He is also the engineering officer aboard the airplane, and maintains a complete log of performance data.

He must be a qualified instrument pilot.

He must be able to fly good formation in any assigned position, day or night.

He must be qualified to navigate by day or at night by pilotage, dead reckoning, and by use of radio aids.

He must be proficient in the operation of all radio equipment located in the pilot's compartment.

In formation flying, he must be able to make engine adjustments almost automatically.

He must be prepared to take over on instruments when the formation is climbing through an overcast, thus enabling you to watch the rest of the formation.

Always remember that the copilot is a fully trained, rated pilot just like yourself. He is subordinate to you only by virtue of your position as the airplane commander. The B-17 is a lot of airplane; more airplane than any one pilot can handle alone over a long period of time. Therefore, you have been provided with a second pilot who will share the duties of flight operation.

Treat your copilot as a brother pilot. Remember that the more proficient he is **as a pilot,** the more efficiently he will be able to perform the duties of the vital post he holds as your second in command.

Be sure that he is allowed to do his share of the flying, in the pilot's seat, on takeoffs, landings, and on instruments.

The importance of the copilot is eloquently testified by airplane commanders overseas. There have been many cases in which the pilot has been disabled or killed in flight and the copilot has taken full command of both airplane and crew, completed the mission, and returned safely to the home base. Usually, the copilots who have distinguished themselves under such conditions have been copilots who have been respected and trained by the airplane commander **as pilots.**

Bear in mind that the pilot in the right-hand seat of your airplane is preparing himself for an airplane commander's post too. Allow him every chance to develop his ability and to profit by your experience.

THE NAVIGATOR

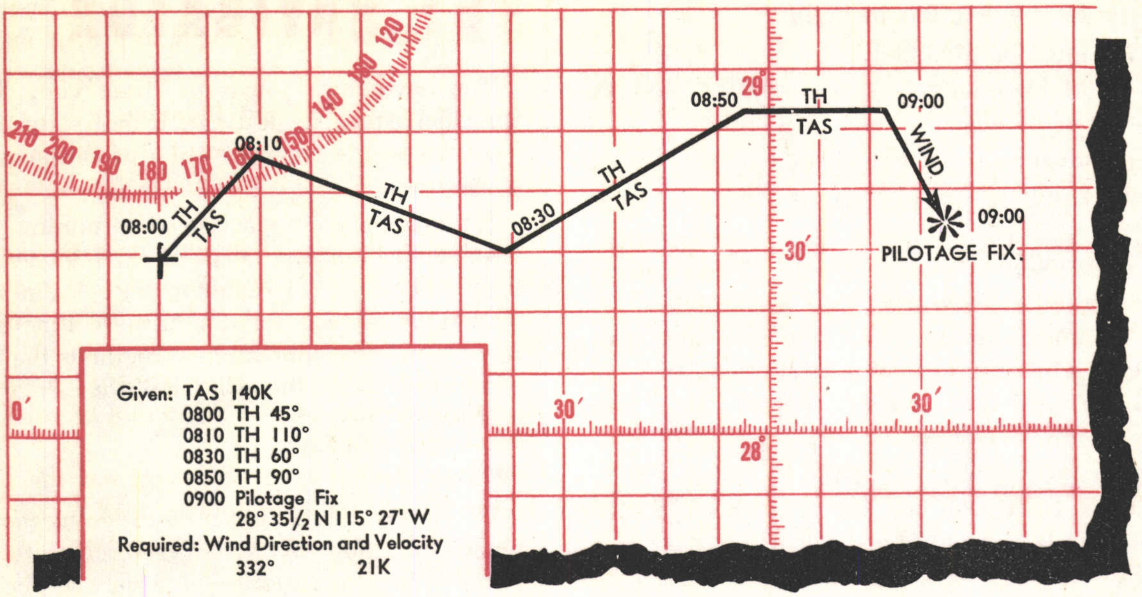
The navigator's job is to direct your flight from departure to destination and return. He must know the exact position of the airplane at all times.

Navigation is the art of determining geographic positions by means of (a) pilotage, (b) dead reckoning, (c) radio, or (d) celestial navigation, or any combination of these 4 methods. By any one or combination of methods the navigator determines the position of the airplane in relation to the earth.

Pilotage

Pilotage is the method of determining the airplane's position by visual reference to the ground. The importance of accurate pilotage cannot be over-emphasized. In combat navigation, all bombing targets are approached by pilotage, and in many theaters the route is maintained by pilotage. This requires not merely the vicinity type, but **pin-point pilotage.** The exact position of the airplane must be known not within 5 miles but within ¼ of a mile.

The navigator does this by constant reference to groundspeeds and ETA's established for points ahead, the ground, and to his maps and charts. During the mission, so long as he can maintain visual contact with the ground, the navigator can establish these pin-point positions so that the exact track of the airplane will be known when the mission is completed.



Dead Reckoning

Dead reckoning is the basis of all other types of navigation. For instance, if the navigator is doing pilotage and computes ETA's for points ahead, he is using dead reckoning.

Dead reckoning determines the position of the airplane at any given time by keeping an account of the track and distance flown over the earth's surface from the point of departure or the last known position.

Dead reckoning can be subdivided into two classes:

1. **Dead reckoning as a result of a series of known positions obtained by some other means of navigation.** For example, you, as pilot, start on a mission from London to Berlin at 25,000 feet. For the first hour your navigator keeps track by pilotage; at the same time recording the heading and airspeed which you are holding. According to plan, at the end of the first hour the airplane goes above the clouds, thus losing contact with the ground. By means of dead reckoning from his last pilotage point, the navigator is able to tell the position of the aircraft at any time. The first hour's travel has given him the wind prevalent at altitude, and the track and groundspeed being made. By computing track and distance from the last pilotage point, he can always tell the position of the airplane. When your airplane comes out of the clouds near Berlin, the navigator will have a very close approximation of his exact position, and will be able to pick up pilotage points quickly.

2. **Dead reckoning as a result of visual references other than pilotage.** When flying over water, desert, or barren land, where no reliable pilotage points are available, accurate DR navigation still can be performed. By means of the drift meter the navigator is able to determine drift, the angle between the heading of the airplane and its track over the ground. The true heading of the airplane is obtained by application of compass error to the compass reading. The true heading plus or minus the drift (as read on the drift meter) gives the track of the airplane. At a constant airspeed, drift on 2 or more headings will give the navigator information necessary to obtain the wind by use of his computer. Groundspeed is computed easily once the wind, heading, and airspeed are known. So, by constant recording of true heading, true airspeed, drift, and groundspeed, the navigator is able to determine accurately the position of the airplane at any given time. For greatest accuracy, the pilot must maintain constant courses and airspeeds. If course or airspeed is changed, notify the navigator so he can record these changes.

Radio

Radio navigation makes use of various radio aids to determine position. The development of many new radio devices has increased the use of radio in combat zones. However, the ease with which radio aids can be jammed, or bent, limits the use of radio to that of a check on DR and pilotage. The navigator, in conjunction with the radio man, is responsible for all radio procedures, approaches, etc., that are in effect in the theater.

Celestial

Celestial navigation is the science of determining position by reference to 2 or more celestial bodies. The navigator uses a sextant, accurate time, and many tables to obtain what he calls a line of position. Actually this line is part of a circle on which the altitude of the particular body is constant for that instant of time. An intersection of 2 or more of these lines gives the navigator a fix. These fixes can be relied on as being accurate within approximately 10 miles. One reason for inaccuracy is the instability of the airplane as it moves through space, causing acceleration of the sextant bubble (a level denoting the horizontal). Because of this acceleration, the navigator takes observations over a period of time so that the acceleration error will cancel out to some extent. If the navigator tells the pilot when he wishes to take an observation, extremely careful flying on the part of the pilot during the few minutes it takes to make the observation will result in much greater accuracy. Generally speaking, the only celestial navigation used by a combat crew is during the delivering flight to the theater. But in all cases celestial navigation is used as a check on dead reckoning and pilotage except where celestial is the only method available, such as on long over-water flights, etc.

Instrument Calibration

Instrument calibration is an important duty of the navigator. All navigation depends directly on the accuracy of his instruments. Correct calibration requires close cooperation and extremely careful flying by the pilot. Instruments to be calibrated include the altimeter, all compasses, airspeed indicators, alignment of the astrocompass, astrograph, and drift meter, and check on the navigator's sextant and watch.

Pilot-Navigator Preflight Planning

1. Pilot and navigator must study flight plan of the route to be flown and select alternate airfields.
2. Study the weather with the navigator. Know what weather you are likely to encounter. Decide what action is to be taken. Know the weather conditions at the alternate airfields.
3. Inform your navigator at what airspeed and altitude you wish to fly so that he can prepare his flight plan.
4. Learn what type of navigation the navigator intends to use: pilotage, dead reckoning, radio, celestial, or a combination of all methods.
5. Determine check points; plan to make radio fixes.
6. Work out an effective communication method with your navigator to be used in flight.
7. Synchronize your watch with your navigator's.

Pilot-Navigator in Flight

1. **Constant course**—For accurate navigation, the pilot—you—must fly a constant course. The navigator has many computations and entries to make in his log. Constantly changing course makes his job more difficult. A good navigator is supposed to be able to follow the pilot, but he cannot be taking compass readings all the time.
2. **Constant airspeed** must be held as nearly as possible. This is as important to the navigator as is a constant course in determining position.
3. **Precision flying** by the pilot greatly affects the accuracy of the navigator's instrument readings, particularly celestial readings. A slight error in celestial reading can cause considerable error in determining positions. You can help the navigator by providing as steady a platform as possible from which he can take readings. The navigator should notify you when he intends to take readings so that the airplane can be leveled off and flown as smoothly as possible, preferably by using the automatic pilot.

Do not allow your navigator to be disturbed while he is taking celestial readings.

4. **Notify the navigator of any change in flight,** such as change in altitude, course, or airspeed. If change in flight plan is to be made, consult the navigator. Talk over the proposed change so that he can plan the flight and advise you about it.

5. If there is doubt about the position of the airplane, pilot and navigator should get together, refer to the navigator's flight log, talk the problem over and decide together the best course of action to take.

6. Check your compasses at intervals with those of the navigator, noting any deviation.

7. Require your navigator to give position reports at intervals.

8. You are ultimately responsible for getting the airplane to its destination. Therefore, it is your duty to know your position at all times.

9. Encourage your navigator to use as many navigation methods as possible as a means of double-checking.

Post-flight Critique

After every flight, get together with the navigator and discuss the flight and compare notes. Go over the navigator's log. If there have been serious navigational errors, discuss them with the navigator and determine their cause. If the navigator has been at fault, caution him that it is his job to see that the same mistake does not occur again. If the error has been caused by faulty instruments, see that they are corrected before another navigation mission is attempted. If your flying has contributed to inaccuracy in navigation, try to fly a better course next time.

Other Duties

The navigator's primary duty is navigating your airplane with a high degree of accuracy. But as a member of the team, he must also have a general knowledge of the entire operation of the airplane.

He has a .50-cal. machine gun at his station, and he must be able to use it skillfully and to service it in emergencies.

He must be familiar with the oxygen system, know how to operate the turrets, radio equipment, and fuel transfer system.

He must know the location of all fuses and spare fuses, lights and spare lights, affecting navigation.

He must be familiar with emergency procedures, such as the manual operation of landing gear, bomb bay doors, and flaps, and the proper procedures for crash landings, ditching, bailout, etc.

THE BOMBARDIER

Accurate and effective bombing is the ultimate purpose of your entire airplane and crew. Every other function is preparatory to hitting and destroying the target.

That's your bombardier's job. The success or failure of the mission depends upon what he accomplishes in that short interval of the bombing run.

When the bombardier takes over the airplane for the run on the target, he is in absolute command. He will tell you what he wants done, and until he tells you "Bombs away," his word is law.

A great deal, therefore, depends on the understanding between bombardier and pilot. You expect your bombardier to know his job when he takes over. He expects you to understand the problems involved in his job, and to give him full cooperation. Teamwork between pilot and bombardier is essential.

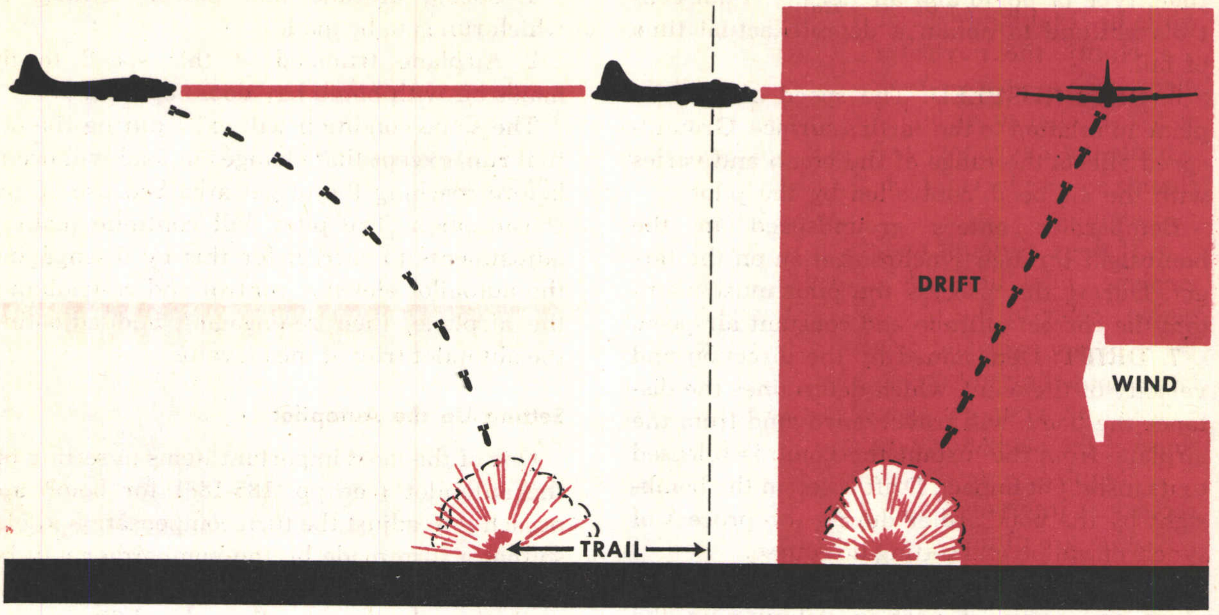
Under any given set of conditions—groundspeed, altitude, direction, etc.—there is only one point in space where a bomb may be released from the airplane to hit a predetermined object on the ground.

There are many things with which a bombardier must be thoroughly familiar in order to release his bombs at the right point to hit this predetermined target.

He must know and understand his bombsight, what it does, and how it does it.

He must thoroughly understand the operation and upkeep of his bombing instruments and equipment.

He must know that his racks, switches, controls, releases, doors, linkage, etc., are in first-class operating condition.



He must understand the automatic pilot as it pertains to bombing.

He must know how to set it up, make any adjustments and minor repairs while in flight.

He must know how to operate all gun positions in the airplane.

He must know how to load and clear simple stoppages and jams of machine guns while in flight.

He must be able to load and fuse his own bombs.

He must understand the destructive power of bombs and must know the vulnerable spots on various types of targets.

He must understand the bombing problem, bombing probabilities, bombing errors, etc.

He must be thoroughly versed in target identification and in aircraft identification.

The bombardier should be familiar with the duties of all members of the crew and should be able to assist the navigator in case the navigator becomes incapacitated.

For the bombardier to be able to do his job, the pilot of the aircraft must place the aircraft in the proper position to arrive at a point on a circle about the target from which the bombs can be released to hit the target.

Consider the following conditions which affect the bomb dropped from an airplane:—

1. **ALTITUDE:** Controlled by the pilot. Determines the length of time the bomb is sustained in flight and affected by atmospheric conditions, thus affecting the range (forward travel of the bomb) and deflection (distance the bomb drifts in a crosswind with respect to airplane's ground track).

2. **TRUE AIRSPEED:** Controlled by the pilot. The measure of the speed of the airplane through the air. It is this speed which is imparted to the bomb and which gives the bomb its initial forward velocity and, therefore, affects the trail of the bomb, or the distance the bomb lags behind the airplane at the instant of impact.

3. **BOMB BALLISTICS:** Size, shape and density of the bomb, which determines its air resistance. Bombardier uses bomb ballistics tables to account for type of bomb.

4. **TRAIL:** Horizontal distance the bomb is behind the airplane at the instant of impact. This value, obtained from bombing tables, is set in the sight by the bombardier. Trail is affected by altitude, airspeed, bomb ballistics and air density, the first 2 factors being controlled by the pilot.

5. **ACTUAL TIME OF FALL:** Length of time the bomb is sustained in air from instant of release to instant of impact. Affected by alti-

tude, type of bomb and air density. Pilot controls altitude to obtain a definite actual time of fall.

6. **GROUNDSPEED:** The speed of the airplane in relation to the earth's surface. Groundspeed affects the range of the bomb and varies with the airspeed, controlled by the pilot.

Bombardier enters groundspeed in the bombsight through synchronization on the target. During this process the pilot must maintain the correct altitude and constant airspeed.

7. **DRIFT:** Determined by the direction and velocity of the wind, which determines the distance the bomb will travel downwind from the airplane from the instant the bomb is released to its instant of impact. Drift is set on the bombsight by the bombardier during the process of synchronization and setting up course.

The above conditions indicate that the pilot plays an important part in determining the proper point of release of the bomb. Moreover, throughout the course of the run, as explained below, there are certain preliminaries and techniques which the pilot must understand to insure accuracy and minimum loss of time.

Prior to takeoff the pilot must ascertain that the airplane's flight instruments have been checked and found accurate. These are the altimeter, airspeed indicator, free air temperature gauge and all gyro instruments. These instruments must be used to determine accurately the airplane's attitude.

The Pilot's Preliminaries

The autopilot and PDI should be checked for proper operation. It is very important that PDI and autopilot function perfectly in the air; otherwise it will be impossible for the bombardier to set up an accurate course on the bombing run. The pilot should thoroughly familiarize himself with the function of both the C-1 autopilot and PDI.

If the run is to be made on the autopilot, the pilot must carefully adjust the autopilot before reaching the target area. The autopilot must be adjusted under the same conditions that will exist on the bombing run over the target. For this reason the following factors should be taken into consideration and duplicated for initial adjustment.

1. Speed, altitude and power settings at which run is to be made.
2. Airplane trimmed at this speed to fly hands off with bomb bay doors opened.

The same condition will exist during the actual run, except that changes in load will occur before reaching the target area because of gas consumption. The pilot will continue making adjustments to correct for this by disengaging the autopilot elevator control and re-trimming the airplane, then re-engaging and adjusting the autopilot trim of the elevator.

Setting Up the Autopilot

One of the most important items in setting up the autopilot (see pp. 185-188) for bomb approach is to adjust the turn compensation knobs so that a turn made by the bombardier will be coordinated and at constant altitude. Failure to make this adjustment will involve difficulty and delay for the bombardier in establishing an accurate course during the run—with the possibility that the bombardier may not be able to establish a proper course in time, the result being considerably large deflection errors in point of impact.

Uncoordinated turns by the autopilot on the run cause erratic lateral motion of the course hair of the bombsight when sighting on target. The bombardier in setting up course must eliminate any lateral motion of the fore-and-aft hair in relation to the target before he has the proper course set up. Therefore, any erratic motion of the course hair requires an additional correction by the bombardier, which would not be necessary if autopilot was adjusted to make coordinated turns.

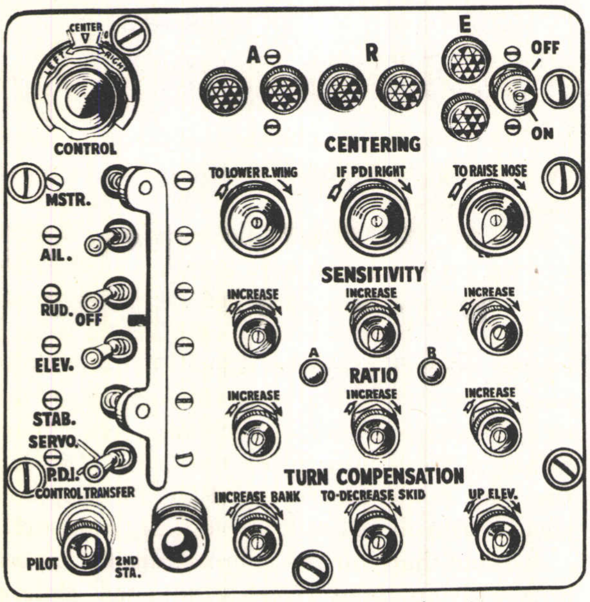
USE OF THE PDI: The same is true if PDI is used on the bomb run. Again, coordinated smooth turns by the pilot become an essential part of the bomb run. In addition to added course corrections necessitated by uncoordinated turns, skidding and slipping introduce small changes in airspeed affecting synchronization of the bombsight on the target. To help the pilot flying the run on PDI, the airplane should be trimmed to fly practically hands off.

Assume that you are approaching the target area with autopilot properly adjusted. Before

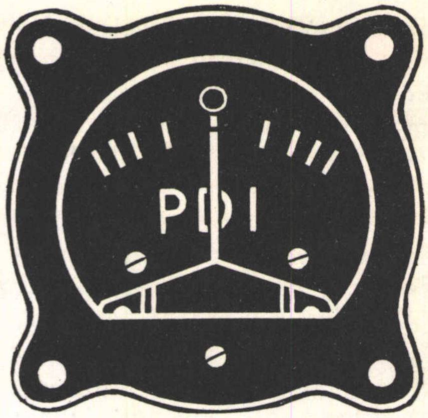
reaching the initial point (beginning of bomb run) there is evasive action to be considered. Many different types of evasive tactics are employed, but from experience it has been recommended that the method of evasive action be left up to the bombardier, since the entire antiaircraft pattern is fully visible to the bombardier in the nose.

EVASIVE ACTION: Changes in altitude necessary for evasive action can be coordinated with the bombardier's changes in direction at specific intervals. This procedure is helpful to the bombardier since he must select the initial point at which he will direct the airplane onto the briefed heading for the beginning of the bomb run.

Should the pilot be flying the evasive action on PDI (at the direction of the bombardier) he must know the exact position of the initial point for beginning the run, so that he can fly the airplane to that point and be on the briefed heading. Otherwise, there is a possibility of beginning to run too soon, which increases the airplane's vulnerability, or beginning the run too late, which will affect the accuracy of the bombing. For best results the approach should be planned so the airplane arrives at the initial point on the briefed heading, and at the assigned bombing altitude and airspeed.



AUTOPILOT



PILOT'S DIRECTIONAL INDICATOR

At this point the bombardier and pilot as a team should exert an extra effort to solve the problem at hand. It is now the bombardier's responsibility to take over the direction of flight, and give directions to the pilot for the operations to follow. The pilot must be able to follow the bombardier's directions with accuracy and minimum loss of time, since the longest possible bomb run seldom exceeds 3 minutes. Wavering and indecision at this moment are disastrous to the success of any mission, and during the crucial portion of the run, flak and fighter opposition must be ignored if bombs are to hit the target. The pilot and bombardier should keep each other informed of anything which may affect the successful completion of the run.

HOLDING A LEVEL: Either before or during the run, the bombardier will ask the pilot for a level. This means that the pilot must accurately level his airplane with his instruments (ignoring the PDI). There should be no acceleration of the airplane in any direction, such as an increase or decrease in airspeed, skidding or slipping, gaining or losing altitude.

For the level the pilot should keep a close check on his instruments, not by feel or watching the horizon. Any acceleration of the airplane during this moment will affect the bubbles (through centrifugal force) on the bombsight gyro, and the bombardier will not be able to establish an accurate level.

For example, assume that an acceleration occurred during the moment the bombardier was accomplishing a level on the gyro. A small

increase in airspeed or a small skid, hardly perceptible, is sufficient to shift the gyro bubble liquid 1° or more. An erroneous tilt of 1° on the gyro will cause an error of approximately 440 feet in the point of impact of a bomb dropped from 20,000 feet, the direction of error depending on direction of tilt of gyro caused by the erroneous bubble reading.

HOLDING ALTITUDE AND AIRSPEED: As the bombardier proceeds to set up his course (synchronize), it is absolutely essential that the pilot maintain the selected altitude and airspeed within the closest possible limits. For every additional 100 feet above the assumed 20,000-foot bombing altitude, the bombing error will increase approximately 30 feet, the direction of error being over. For erroneous airspeed, which creates difficulty in synchronization on the target, the bombing error will be approximately 170 feet for a 10 mph change in airspeed. Assuming the airspeed was 10 mph in excess, from 20,000 feet, the bomb impact would be short 170 feet.

The pilot's responsibility to provide a level and to maintain a selected altitude and airspeed within the closest limits cannot be over-emphasized.

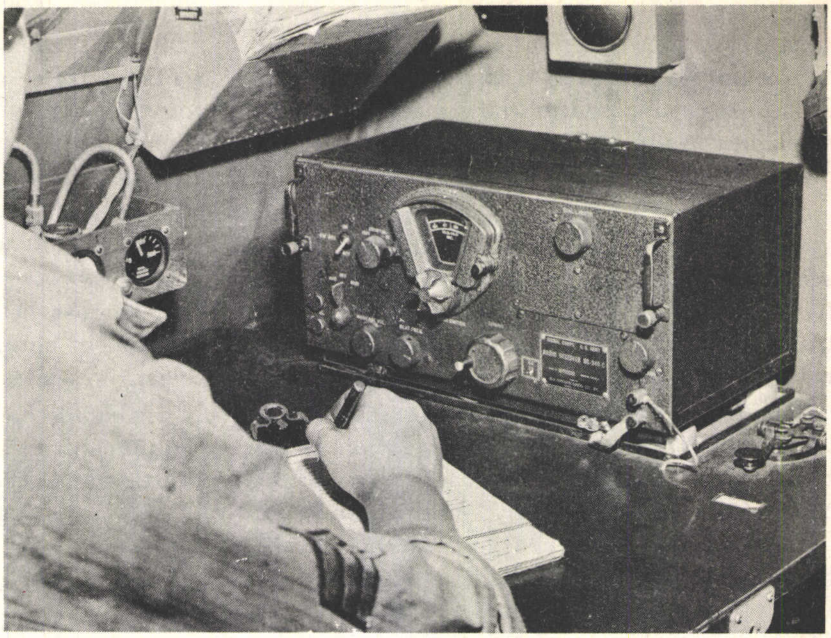
If the pilot is using PDI (at the direction of the bombardier) instead of autopilot, he must be thoroughly familiar with the corrections demanded by the bombardier. Too large a correction or too small a correction, too soon or too late, is as bad as no correction at all. Only through prodigious practice flying with the PDI can the pilot become proficient to a point where he can actually perform a coordinated turn, the amount and speed necessary to balance the bombardier's signal from the bombsight.

Erratic airspeeds, varying altitudes, and poorly coordinated turns make the job of establishing course and synchronizing doubly difficult for both pilot and bombardier, because of the necessary added corrections required. The resulting bomb impact will be far from satisfactory.

After releasing the bombs, the pilot or bombardier may continue evasive action—usually the pilot, so that the bombardier may man his guns.

The pilot using the turn control may continue to fly the airplane on autopilot, or fly it manually, with the autopilot in a position to be engaged by merely flipping the lock switches. This would provide potential control of the airplane in case of emergency.

REDUCING CIRCULAR ERROR: One of the greatest assets towards reducing the circular error of a bombing squadron lies in the pilot's ability to adjust the autopilot properly, fly the PDI, and maintain the designated altitude and airspeeds during the bombing run. Reducing the circular error of a bombing squadron reduces the total number of aircraft required to destroy a particular target. For this reason both pilot and bombardier should work together until they have developed a complete understanding and confidence in each other.



THE RADIO OPERATOR

There is a lot of radio equipment in today's B-17's. There is one man in particular who is supposed to know all there is to know about this equipment. Sometimes he does, but often he doesn't. And when the radio operator's deficiencies do not become apparent until the crew is in the combat zone, it is then too late. Too often the lives of pilots and crew are lost because the radio operator has accepted his responsibility indifferently.

Radio is a subject that cannot be learned in a day. It cannot be mastered in 6 weeks, but sufficient knowledge can be imparted to the radio man during his period of training in the United States if he is willing to study. It is imperative that you check your radio operator's ability to handle his job before taking him overseas as part of your crew. To do this you may have to check the various departments to find any weakness in the radio operator's training and proficiency and to aid the instructors in overcoming such weaknesses.

Training in the various phases of the heavy bomber program is designed to fit each member of the crew for the handling of his jobs. The radio operator will be required to:

1. Render position reports every 30 minutes.
2. Assist the navigator in taking fixes.
3. Keep the liaison and command sets properly tuned and in good operating order.
4. Understand from an operational point of view: Instrument landing, IFF, VHF and other navigational aids equipment in the airplane.
5. Maintain a log.
6. Preflight radio equipment.
7. Understand emergency and Direction Finding procedures.
8. Understand the use of codes and authentication procedures.

In addition to being a radio operator, the radio man is also a gunner. During periods of combat he will be required to leave his watch at the radio and take up his guns. He is often required to learn photography. Some of the best pictures taken in the Southwest Pacific were taken by radio operators. The radio operator who cannot perform his job properly may be the weakest member of your crew—and the crew is no stronger than its weakest member.

THE ENGINEER

Size up the man who is to be your engineer. This man is supposed to know more about the airplane you are to fly than any other member of the crew.

He has been trained in the Air Forces' highly specialized technical schools. Probably he has served some time as a crew chief. Nevertheless, there may be some inevitable blank spots in his training which you, as a pilot and airplane commander, may be able to fill in.

Think back on your own training. In many courses of instruction, you had a lot of things thrown at you from right and left. You had to concentrate on how to fly; and where your equipment was concerned you learned to rely more and more on the enlisted personnel, particularly the crew chief and the engineer, to advise you about things that were not taught to you because of lack of time and the arrangement of the training program.

Both pilot and engineer have a responsibility to work closely together to supplement and fill in the blank spots in each other's education.

To be a qualified combat engineer a man must know his airplane, his engines, and his armament equipment thoroughly. This is a big responsibility: the lives of the entire crew, the safety of the equipment, the success of the mission depend upon it squarely.

He must work closely with the copilot, checking engine operation, fuel consumption, and the operation of all equipment.

He must be able to work with the bombardier, and know how to cock, lock, and load the bomb racks. It is up to you, the airplane commander, to see that he is familiar with these duties, and, if he is hazy concerning them, to have the bombardier give him special help and instruction.

He must be thoroughly familiar with the armament equipment, and know how to strip, clean, and re-assemble the guns.

He should have a general knowledge of radio equipment, and be able to assist in tuning transmitters and receivers.

Your engineer should be your chief source of information concerning the airplane. He should know more about the equipment than any other crew member—yourself included.

You, in turn, are his source of information concerning flying. Bear this in mind in all your discussions with the engineer. The more complete you can make his knowledge of the reasons behind every function of the equipment, the more valuable he will be as a member of the crew. Who knows? Someday that little bit of extra knowledge in the engineer's mind may save the day in some emergency.

Generally, in emergencies, the engineer will be the man to whom you turn first. Build up his pride, his confidence, his knowledge. Know him personally; check on the extent of his knowledge. Make him a man upon whom you can rely.

THE GUNNERS

The B-17 is a most effective gun platform, but its effectiveness can be either applied or defeated by the way the gunners in your crew perform their duties in action.

Your gunners belong to one of two distinct categories: turret gunners and flexible gunners.

The power turret gunners require many mental and physical qualities similar to what we know as inherent flying ability, since the operation of the power turret and gunsight are much like that of airplane flight operation.

While the flexible gunners do not require the same delicate touch as the turret gunner, they must have a fine sense of timing and be familiar with the rudiments of exterior ballistics.

All gunners should be familiar with the coverage area of all gun positions, and be prepared to bring the proper gun to bear as the conditions may warrant.

They should be experts in aircraft identification. Where the Sperry turret is used, failure to set the target dimension dial properly on the K-type sight will result in miscalculation of range.

They must be thoroughly familiar with the Browning aircraft machine gun. They should know how to maintain the guns, how to clear jams and stoppages, and how to harmonize the sights with the guns.

While participating in training flights, the gunners should be operating their turrets constantly, tracking with the flexible guns even when actual firing is not practical. Other airplanes flying in the vicinity offer excellent tracking targets, as do automobiles, houses, and other ground objects during low altitude flights.

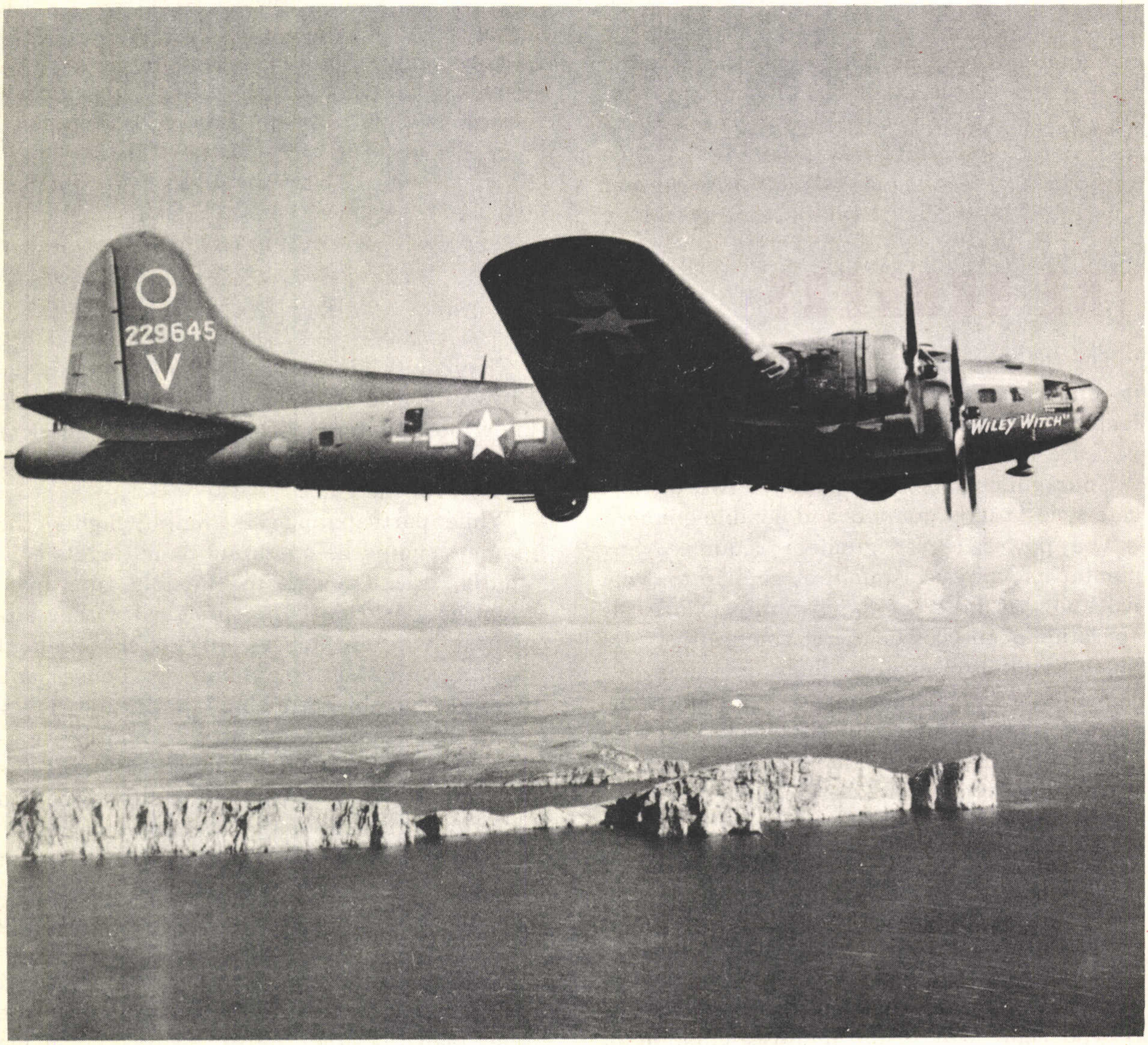
The importance of teamwork cannot be overemphasized. One poorly trained gunner, or one man not on the alert, can be the weak link as a result of which the entire crew may be lost.

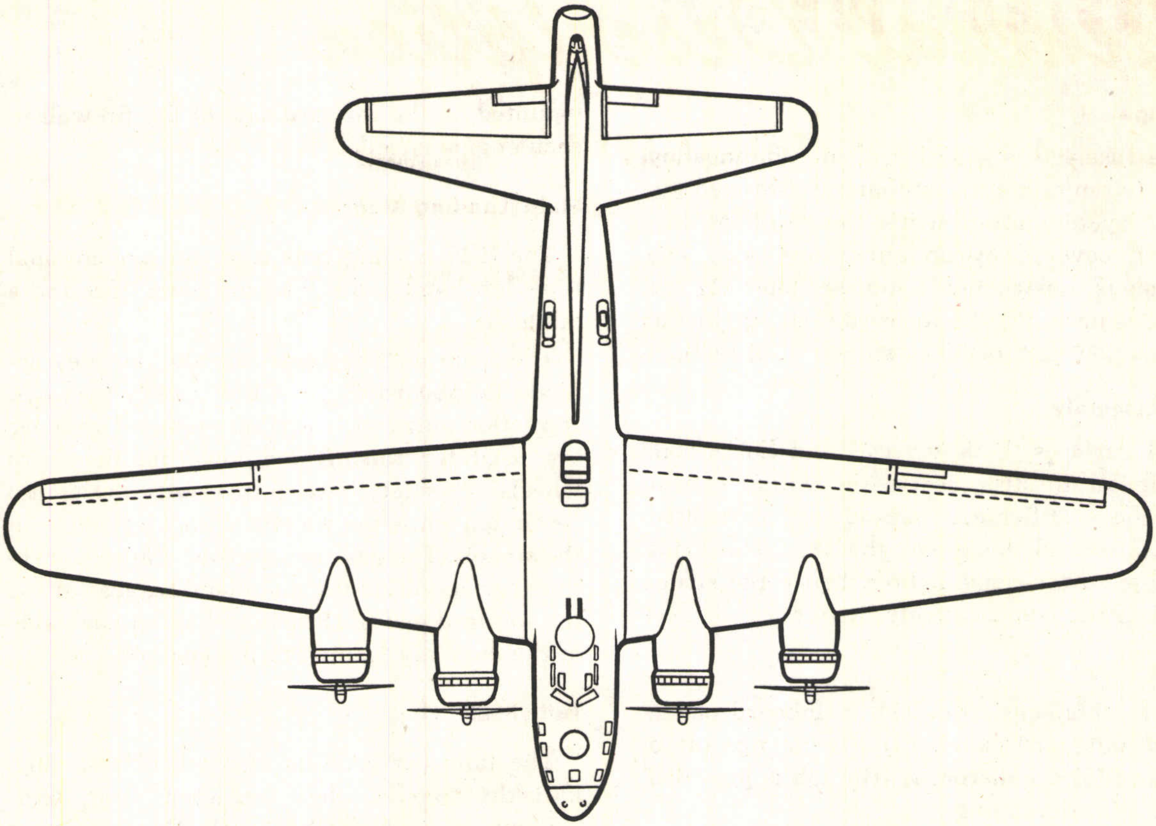
Keep the interest of your gunners alive at all times. Any form of competition among the gunners themselves should stimulate interest to a high degree.

Finally, each gunner should fire the guns at each station to familiarize himself with the other man's position and to insure knowledge of operation in the event of an emergency.

General Description

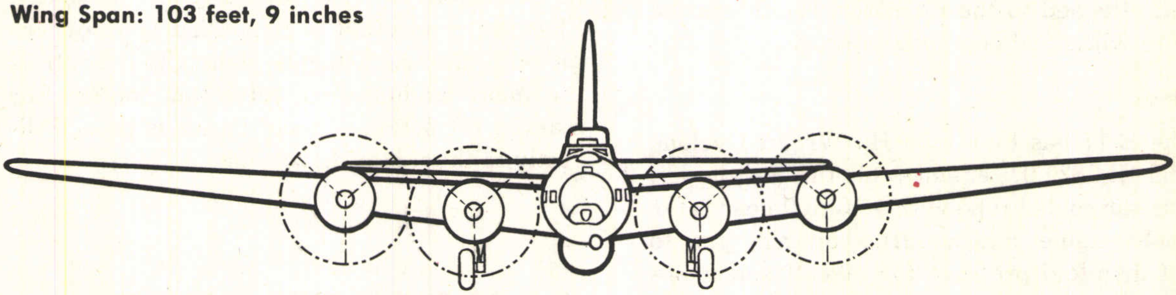
THIS IS THE FLYING FORTRESS, B-17 A 4-ENGINE, MID-WING MONOPLANE OF ALL-METAL, ALUMINUM ALLOY, STRESSED-SKIN CONSTRUCTION.

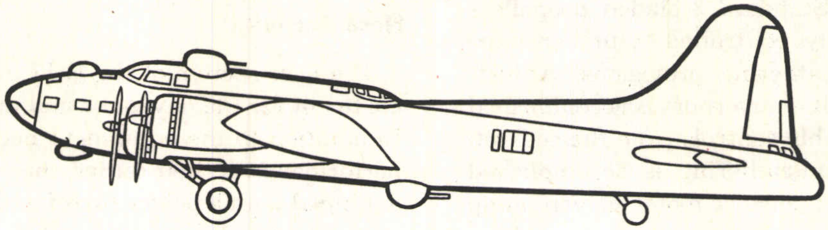




APPROXIMATE OVER-ALL DIMENSIONS:
Length: 74 feet, 9 inches
Height: 19 feet, 1 inch (gear down)
Wing Span: 103 feet, 9 inches

APPROXIMATE WEIGHT:
Tactical empty: 41,000 lb.
Maximum gross: 64,500 lb.





CONSTRUCTION

Fuselage

The fuselage is a series of aluminum alloy rings (circumferential stiffeners) fastened together by aluminum strips (longitudinal stiffeners), covered by an aluminum skin. The fuselage is constructed in four sections: (1) the plexiglas nose; (2) the forward section; (3) the rear section; and (4) the "stinger" tail section.

Tail Assembly

Tail surfaces, both vertical and horizontal, are similar in structure to the wings, except that sheet stiffeners, instead of corrugated sheet, are used to support the skin. The loads on these surfaces are lighter, hence the structure is made comparatively lighter.

Wings

Each wing consists of (1) an inboard panel; (2) an outboard panel; (3) a wing tip; (4) a flap; and (5) an aileron. A trim tab is provided in the left aileron only.

The engine nacelles, of semi-monocoque design, are installed in each inboard wing panel.

The wing construction: spars and highly stressed ribs of the truss type. Corrugated dural sheet, attached to the rib cords, reinforces the skin to withstand compression loads.

Engines

The B-17 has four 1200 Hp Wright Cyclone Model R-1820-97 engines of the 9-cylinder, radial, air-cooled type with a 16-to-9 gear ratio.

Each engine has a turbo-supercharger to boost manifold pressure for takeoff and maintain sea-level pressure at high altitude.

Propellers

The Hamilton Standard 3-bladed propellers are hydromatically controlled with constant-speed and full feathering provisions. Adjustment of the propeller governors is accomplished individually by cable controls from the cockpit. Feathering and unfeathering is accomplished hydraulically by an electric motor-driven pump mounted on the forward side of the firewall in each engine nacelle.

Main Landing Gear

The B-17 landing gear is of the conventional type: left hand and right hand main gear and a tail gear.

The main gear retracts into the nacelles behind the inboard engines. Electrically operated retraction units, with auxiliary manual systems, are used for raising and lowering the main wheels. A safety switch prevents accidental retraction while the weight of the airplane is on the wheels. The emergency hand crank connections for operating the main landing gear are at the forward end of the bomb bay on each side of the doorway leading to the cockpit.

Tailwheel

The tail gear consists of a wheel assembly, knuckle, treadle, oleo, retraction unit, anti-shimmy brake and wheel lock. Provisions are made for 360° rotation of the wheel, and for locking the wheel in a straight fore-and-aft position during takeoff. The tailwheel gear may be retracted either electrically or manually. Electrical retraction is controlled in the cockpit with the same toggle switch that controls the main landing gear retraction motor. For manual retraction, a hand crank is geared directly to the motor drive shaft.

COMPARTMENTS

Nose Section

The nose section of the B-17 provides a compartment for the navigator and the bombardier. In addition to the equipment necessary for the performance of their duties, the compartment is equipped with a power turret and free gun.

Pilot's Compartment

Between the nose section and the bomb bay is the flight deck, or pilot's compartment. This elevated enclosure contains the pilot's and co-pilot's stations with all the essential flight controls, instruments, etc. It is also equipped with a Sperry power turret with twin .50-cal. machine guns.

Bomb Bay

The bomb bay is aft of the pilot's compartment. Provision is made for releasable gasoline tanks in place of a bomb load. One tank may be carried on each side of the bomb truss. Tanks (or bombs) can be released electrically by the bombardier, or can be released by pulling one of the emergency release handles or turning on Salvo switch.

Bomb rack selector switches, installed on either side of the bomb bay, are used in conjunction with the rack selector switches on the bombardier's control panel. When either switch is "OFF" electrical release of bombs and fuel tanks is impossible.

"Tokyo tank" shut-off valves are mounted below the door at aft end of bomb bay. (In some installations these valves are in the radio compartment.)

A relief tube is located behind the dome light in the left bomb bay.

Radio Compartment

The radio compartment is aft of the bomb bay section, and is reached from the flight deck by a catwalk through the bomb bay.

The radio compartment is equipped with one .50-cal. machine gun.

Waist Section

Main entrance and exit is located in the waist section.

Two flexible .50-cal. machine guns are located in the waist gunners' compartment.

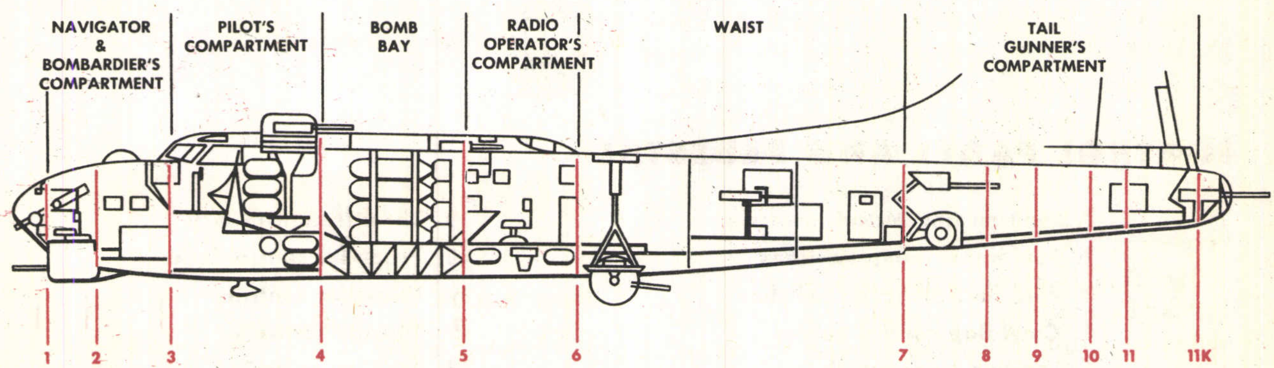
Ball Turret

In the bottom of the waist section (aft of the radio compartment) provision is made for a Sperry ball-type power turret equipped with twin .50-cal. machine guns. This turret can be entered from within the airplane after takeoff.

Tail Gunner's Compartment

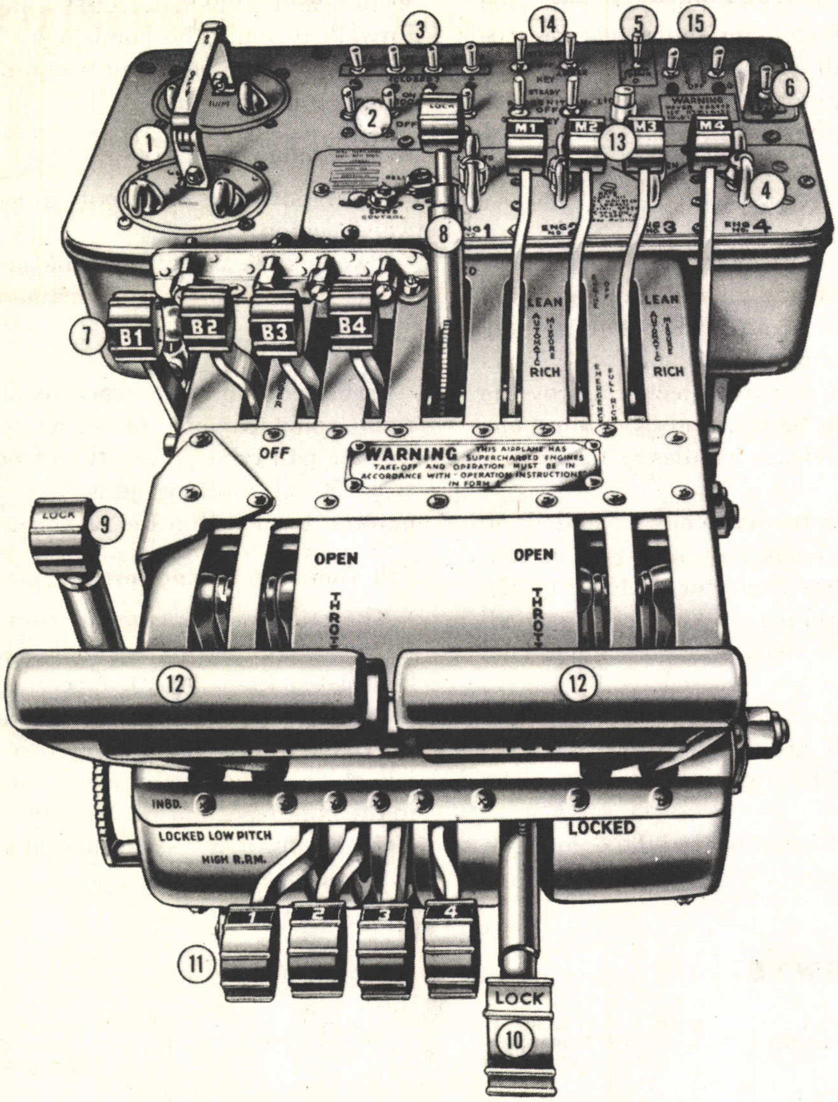
The tail gunner's compartment is in the extreme end of the fuselage and is equipped with 2 direct-sighted .50-cal. machine guns. There are two ways of entering this compartment: (1) from the waist section through the tail-wheel compartment by means of a small door in the bulkhead, and (2) from the outside of the airplane through a small side door. The latter is an emergency exit.

COMPARTMENTS



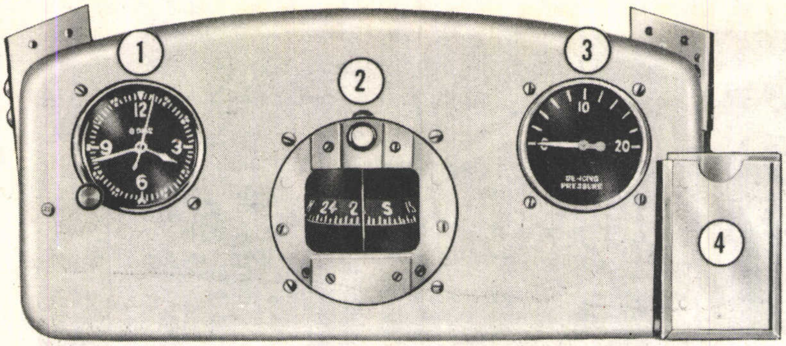
STATIONS

PILOT'S OPERATIONAL EQUIPMENT



CONTROL PANEL AND PEDESTAL

1. Ignition and Master switches
2. Fuel boost pump switches
3. Fuel shut-off valve switches
4. Cowl flap control valves
5. Landing gear switch
6. Wing flap switch
7. Turbo-supercharger controls (oil regulated)
8. Turbo and mixture control lock
9. Throttle control lock
10. Propeller control lock
11. Propeller controls
12. Throttle controls
13. Mixture controls
14. Recognition light switches
15. Landing light switches

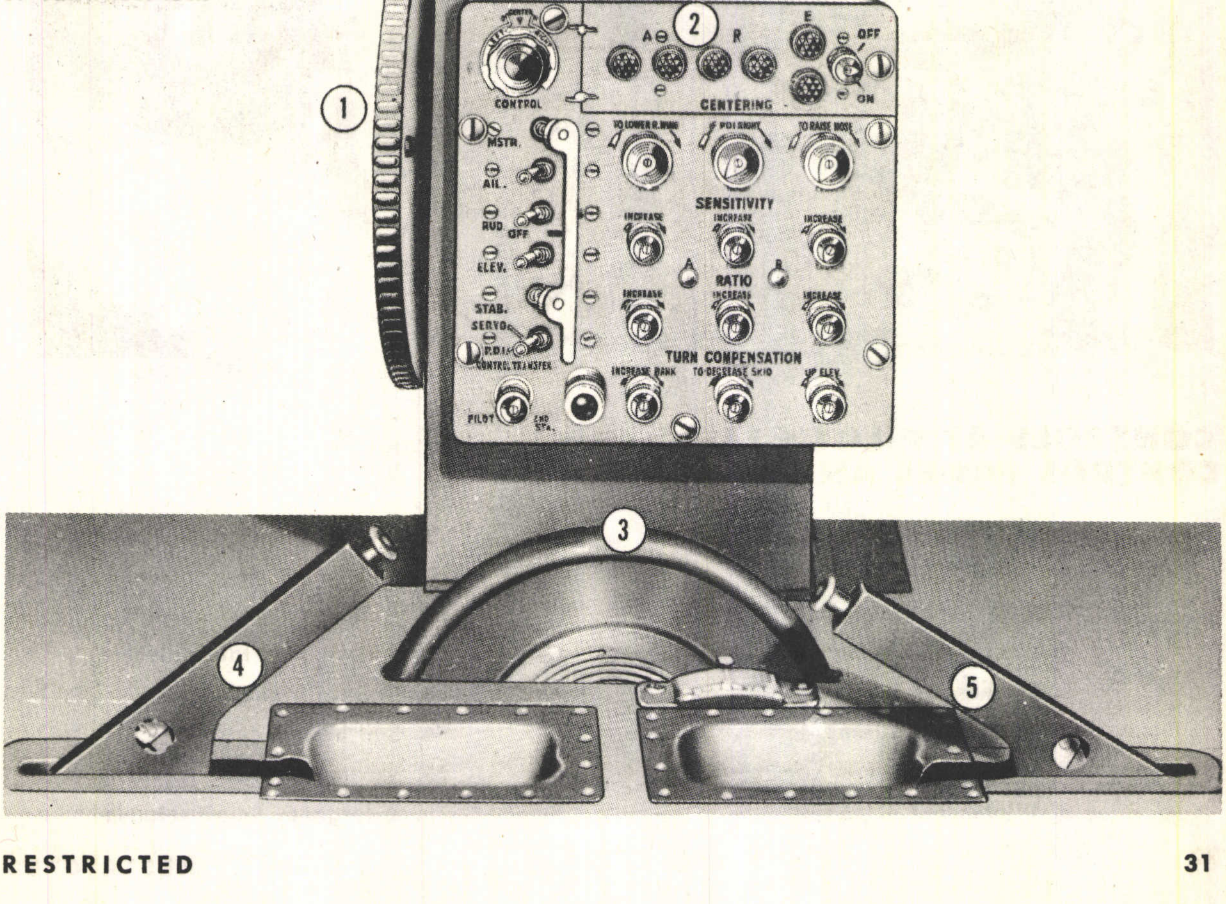


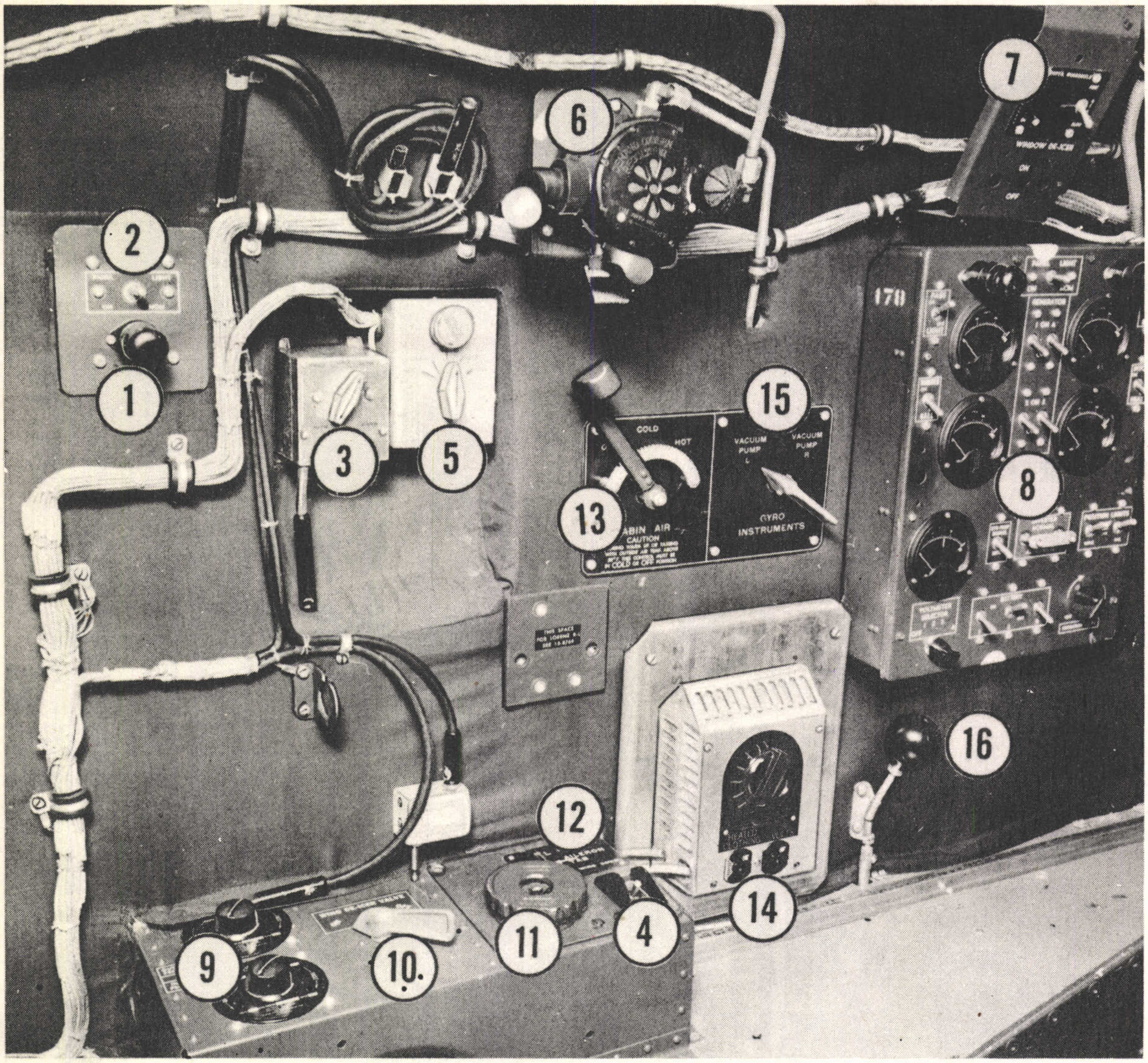
ABOVE WINDSHIELD

1. Clock
2. Compass
3. De-icer pressure gage
4. Compass card

LOWER CONTROL PEDESTAL

1. Elevator trim tab control
2. Automatic flight control panel
3. Rudder tab control
4. Elevator and rudder lock
5. Tailwheel lock



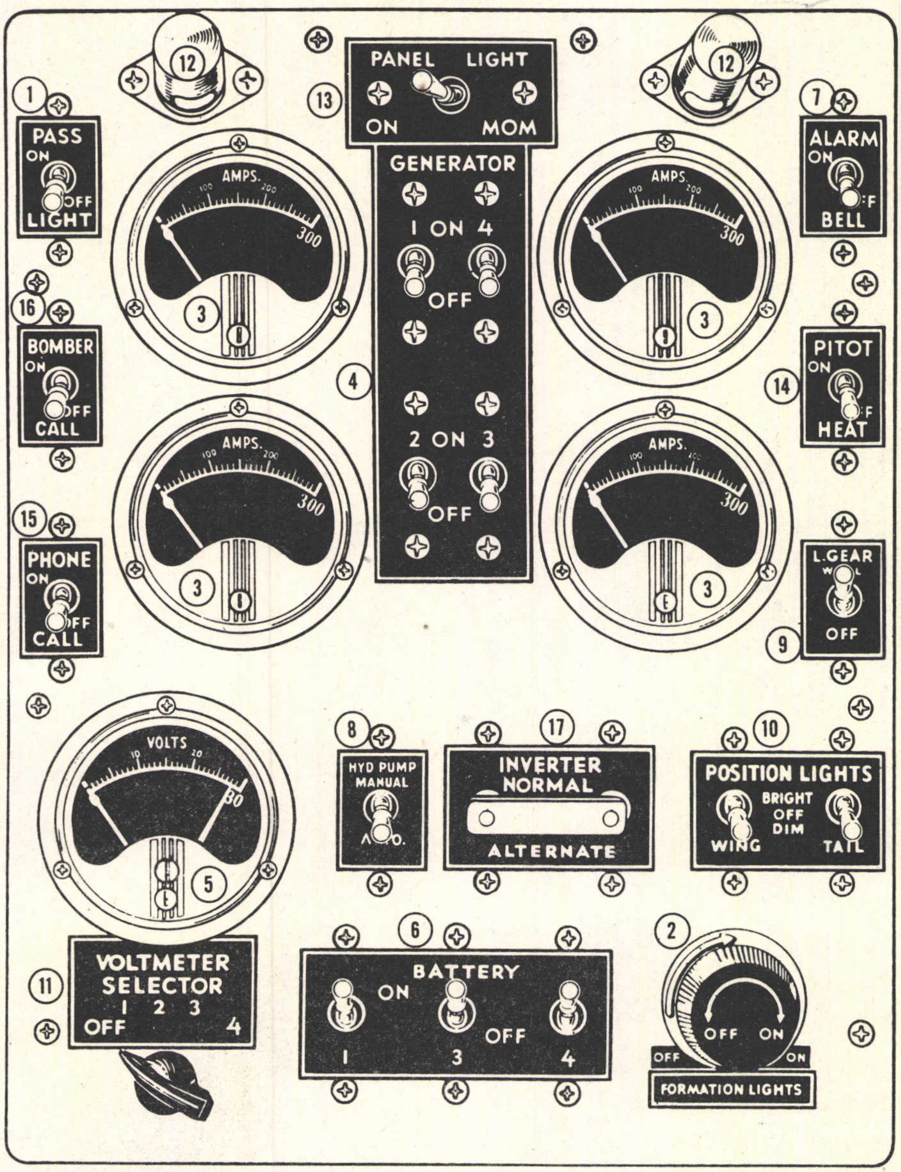


CONTROLS AT PILOT'S LEFT

1. Panel light
2. Panel light switch
3. Filter selector switch
4. Propeller anti-icer switch
5. Interphone jackbox
6. Oxygen regulator
7. Windshield wiper controls
8. Pilot's control panel
9. Propeller anti-icer rheostats
10. Surface de-icer control
11. Aileron trim tab control
12. Aileron trim tab indicator
13. Cabin air control
14. Suit heater outlet
15. Vacuum selector valve
16. Emergency bomb release

PILOT'S CONTROL PANEL

1. Passing light switch
2. Running lights switch
3. Ammeters
4. Generator switches
5. Voltmeter
6. Battery switches
7. Alarm bell switch
8. Hydraulic pump servicing switch
9. Landing gear warning horn switch
10. Position lights switch
11. Voltmeter selector switch
12. Panel lights
13. Panel lights switch
14. Pitot heater switch
15. Interphone call light switch
16. Bomber call light switch
17. Inverter switch (some read "MAIN"—"SPARE")



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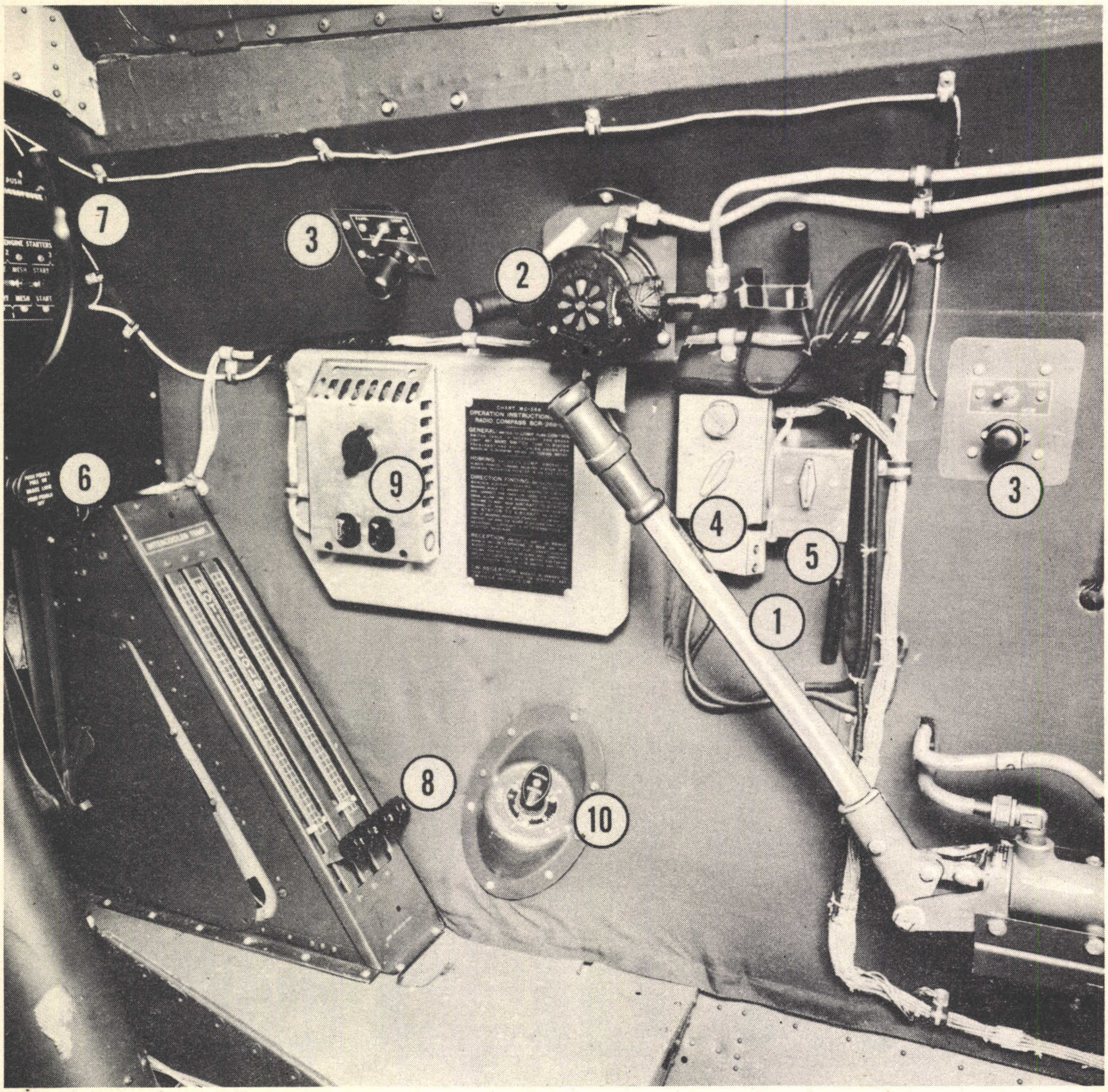
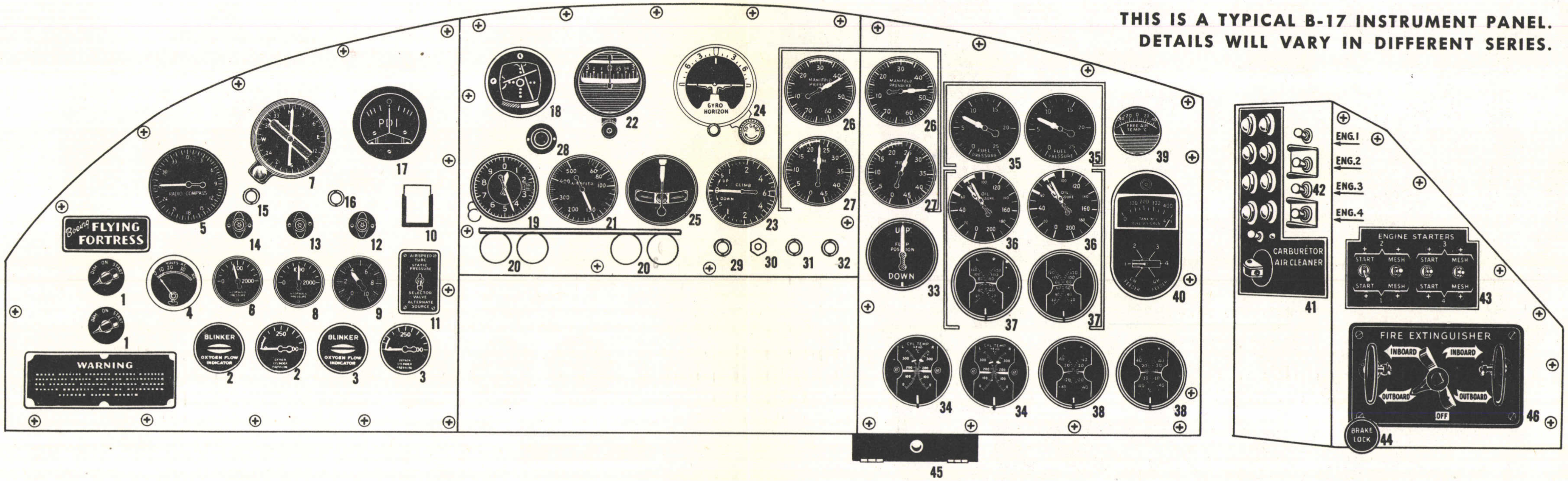


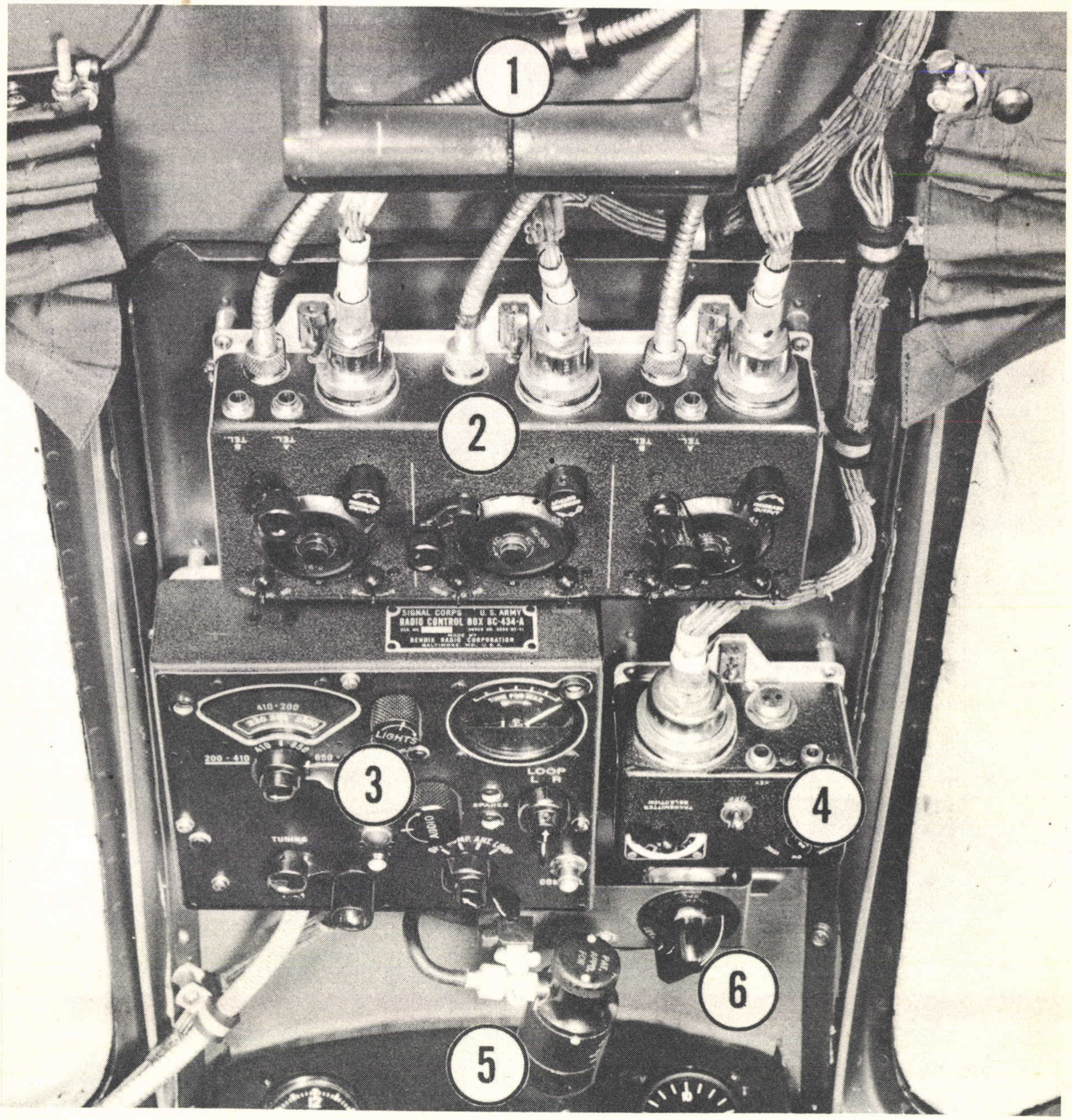
CONTROLS AT COPILOT'S RIGHT

1. Hydraulic hand pump
2. Oxygen regulator
3. Panel light
4. Interphone jackbox
5. Filter selector switch
6. Parking brake
7. Copilot's control wheel
8. Intercooler controls
9. Suit heater outlet
10. Engine primer

B-17 INSTRUMENT PANEL



1. Fluorescent light switches
2. Pilot's oxygen flow indicator and pressure gage
3. Copilot's oxygen flow indicator and pressure gage
4. Voltmeter (AC)
5. Radio compass
6. Emergency oil pressure gage (Not on G)
7. Flux gate compass
8. Hydraulic oil pressure gage
9. Suction gage
10. Altimeter correction card
11. Airspeed alternate source switch
12. Vacuum warning light
13. Main system hydraulic oil warning light
14. Emergency system hydraulic oil warning light (Not on G)
15. Bomb door position light (Not on G)
16. Bomb release light
17. Pilot's directional indicator
18. Pilot's localizer indicator
19. Altimeter
20. Propeller feathering switches
21. Airspeed indicator
22. Directional gyro
23. Rate-of-climb indicator
24. Flight indicator
25. Turn-and-bank indicator
26. Manifold pressure gages
27. Tachometers
28. Marker beacon light
29. Globe test button
30. Bomber call light
31. Landing gear warning light
32. Tailwheel lock light
33. Flap position indicator
34. Cylinder-head temperature gages
35. Fuel pressure gages
36. Oil pressure gages
37. Oil temperature gages
38. Carburetor air temperature gages
39. Free air temperature gage
40. Fuel quantity gage
41. Carburetor air filter switch
42. Oil dilution switches
43. Starting switches
44. Parking brake control
45. Spare fuse box
46. Engine fire extinguisher controls (on some airplanes)



PILOT'S COMPARTMENT CEILING

1. Emergency hand brake
2. Command receiver control unit
3. Radio compass control unit
4. Command transmitter control unit
5. Fluorescent light
6. Fluorescent light switch

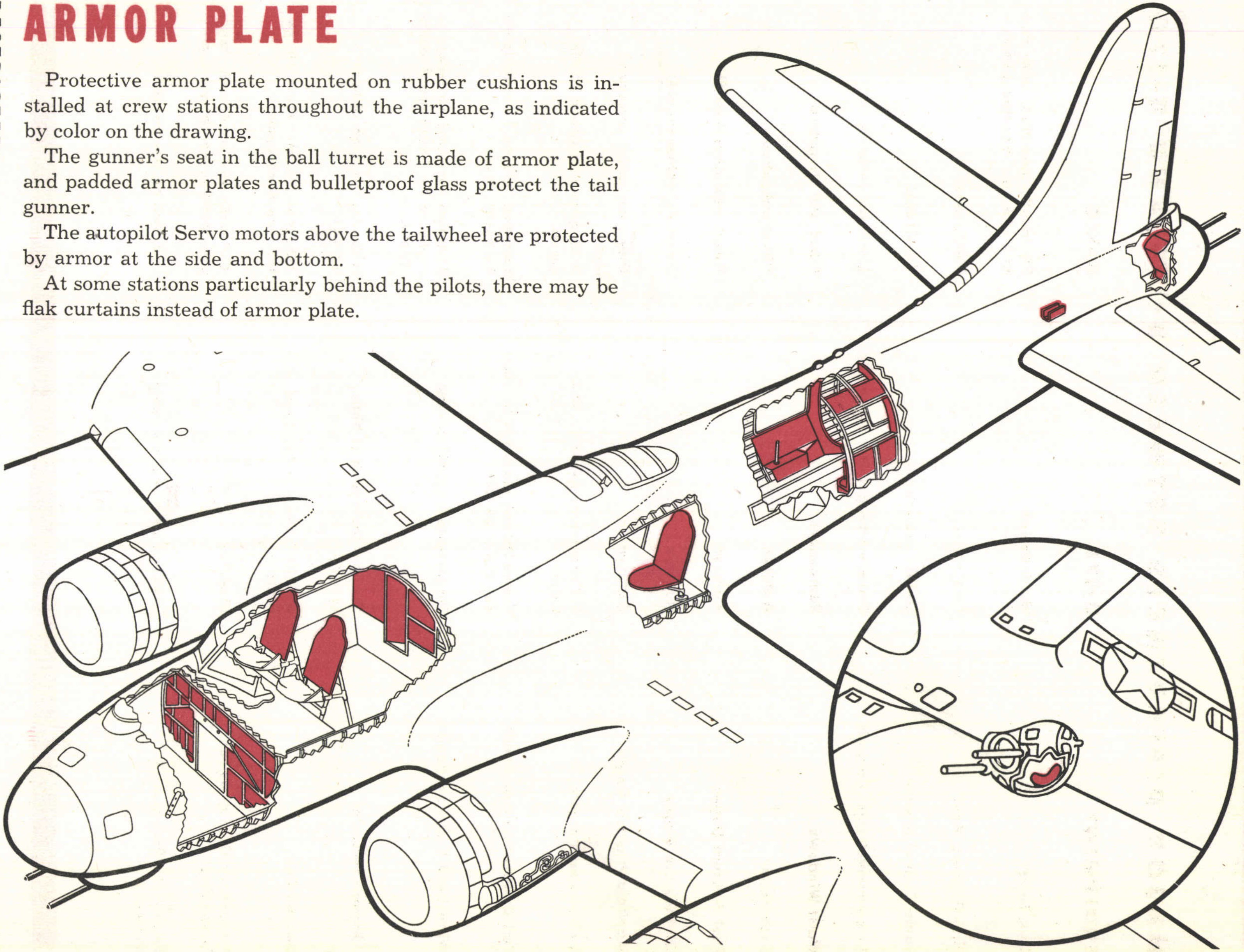
ARMOR PLATE

Protective armor plate mounted on rubber cushions is installed at crew stations throughout the airplane, as indicated by color on the drawing.

The gunner's seat in the ball turret is made of armor plate, and padded armor plates and bulletproof glass protect the tail gunner.

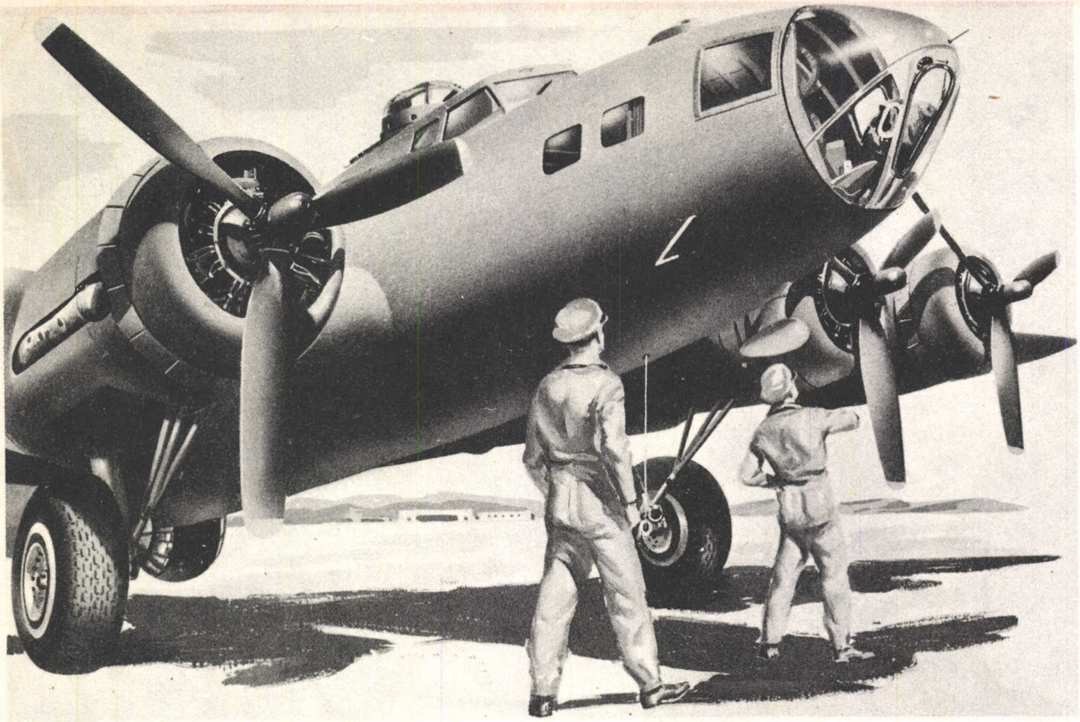
The autopilot Servo motors above the tailwheel are protected by armor at the side and bottom.

At some stations particularly behind the pilots, there may be flak curtains instead of armor plate.



MAJOR DIFFERENCES BETWEEN B-17F AND B-17G

EQUIPMENT	B-17F	B-17G
Chin Turret	Not Installed	Electrically powered, with two M-2 .50 cal. machine guns
Pitot Pressure Mast	Two masts	Single mast
Bomb Control System	Electric and manual	All-electric
Turbo-supercharger Controls	Usually oil regulated controls	Electronic controls
Waist Windows	Removable	Fixed and staggered
Tachometer	Autosyn	Direct indication
Fuel Pressure Gages	Autosyn	Direct indication (liquid)
Oil Pressure Gages	Autosyn	Direct indication (liquid)
Manifold Pressure Gages	Autosyn	Direct indication (pressure)
Turbo-superchargers	B-2 maximum speed 23,400 r.p.m.	B-22 governed speed 26,400 r.p.m.
Tail Gunner's Compartment	Conventional; closed in by canvas cover on tail.	Enlarged; closed in completely by metal cover.
Windshield Knockout Panels	On some late modifications.	Installed on most airplanes or replaced by bullet proof windshields.
Airspeed Indicator	Too low indication at high speeds.	Indicates too high at high speeds.
Booster Coil	Installed. Fires on top dead center.	Induction vibrator firing 20° before top dead center.
Emergency Oil Supply for Feathering	Modified.	Oil tanks equipped with standpipe holding emergency supply.
Engine Fire Extinguisher System	Installed on few early series.	Installed on late airplanes.



INSPECTIONS and Checks

As a rated pilot with a certain number of hours in single engine and 2-engine aircraft to your credit, you are by now thoroughly indoctrinated in the vital importance of systematic and thorough inspections and checks.

That in itself is sufficient reason for you to stop now and reconsider the entire matter as you approach the B-17. For if the inspections and checks which you practiced as a pilot of single or 2-engine aircraft were important, they are doubly important now that you are the commander of one of the largest and most complex military airplanes in the world.

You are the commanding officer of an airplane costing approximately $250,000. You are responsible not only for the safety and efficiency of this valuable equipment but also for the lives of the crew.

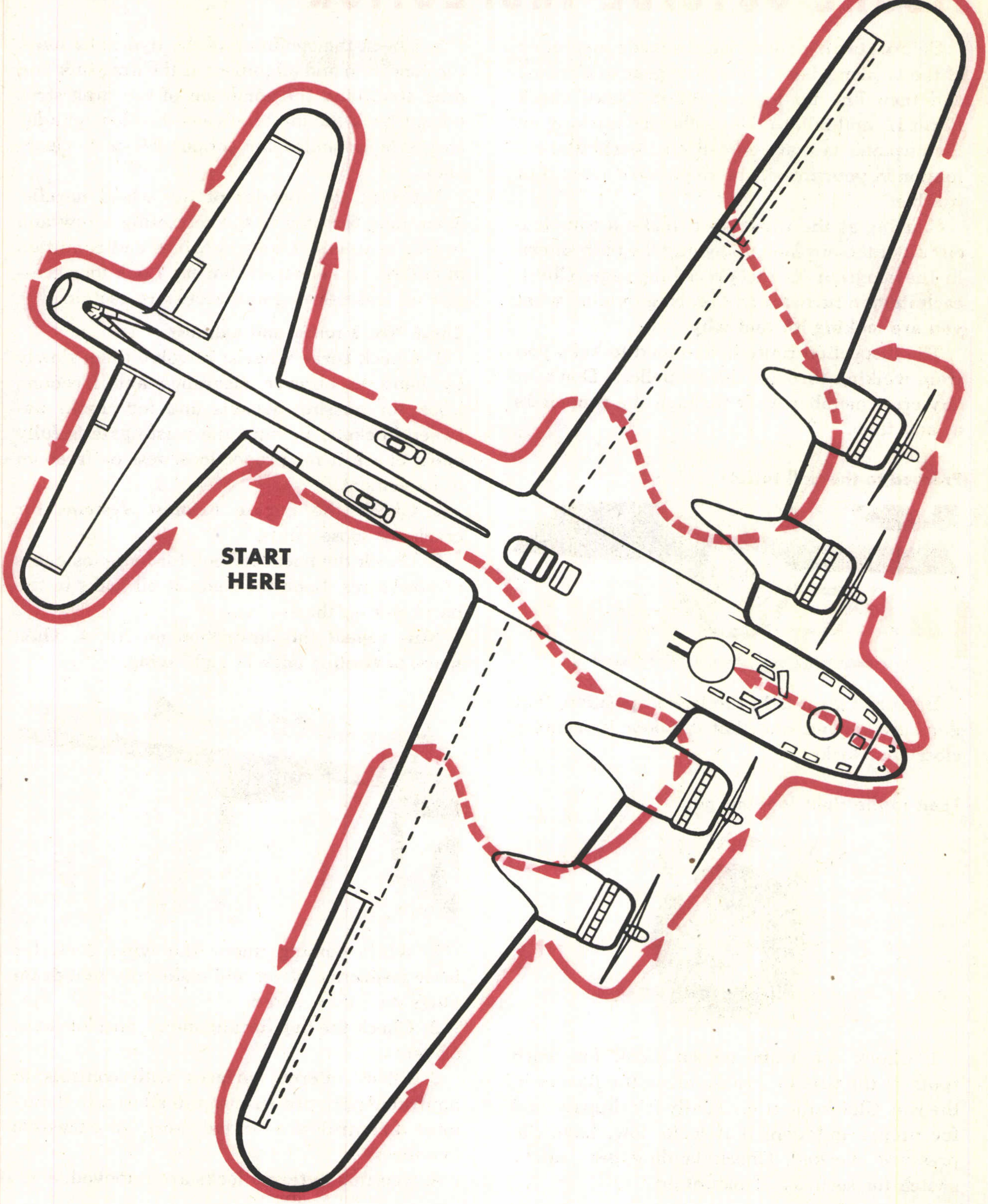
Never take anything for granted about the airplane you are to fly. Not even the best preflight of the airplane by an unquestionably competent ground crew can relieve you of your responsibility to inspect personally the equipment you are about to take into the air. By now your own experience should tell you that **perfect maintenance** is almost an impossibility.

The responsibility is yours, and you can discharge the duties that it implies in one way only: **Check and double-check**.

Follow your routine of inspection scrupulously, and with your eyes wide open. Know what you are looking for and why.

Use your cockpit checklist. Use it properly, and at the indicated times: before starting the engines, before and after takeoff, before landing, on the final approach, after landing, etc.

VISUAL OUTSIDE INSPECTION ROUTE



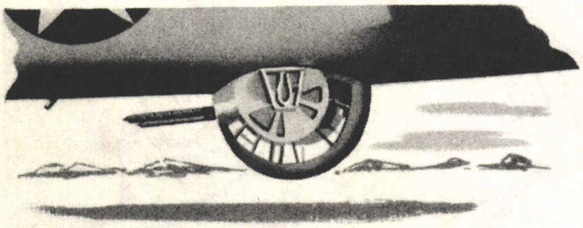
VISUAL OUTSIDE INSPECTION

Before starting your visual outside inspection of the airplane, have crew stow gear in airplane and then line up for inspection. Next, check Form 1A and talk to the mechanics working on the airplane so that you can give particular attention in your inspection to possible sources of trouble.

Starting at the waist door, make a complete circuit of the airplane, following the path shown in the diagram on the preceding page. Check each item in turn, always bearing in mind **what you are looking for and why.**

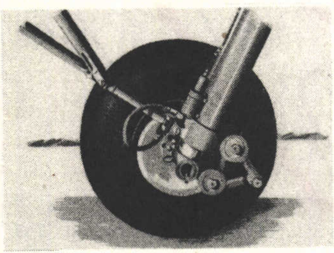
The inspection route is designed to keep you from walking through the propellers. Don't let any crew member walk through the propellers at any time.

Proceed to the ball turret



Be sure that it is in the locked position, that guns are stowed, and that the door is securely closed and locked.

Then to the right landing gear



1. Check the **main wheel:** Look for worn spots on the tire, for cracks along the flanges in the rim. Check the tire visually for slippage and for proper inflation; if it looks low, have the pressure checked. Check landing gear safety switch for security of mounting.

2. Check the condition of the **hydraulic lines,** the condition and alignment of the **drag link** and **drag strut,** and the condition of the drag strut bolts. Check the joint between the oleo cylinder and axle knuckles for proper 1½-inch clearance.

3. Check the interior of the **wheel nacelle,** examining for play in the retracting screw and testing tautness of control cables and condition of pulleys and electrical wiring. Look for excessive oil leaks throughout accessory section.

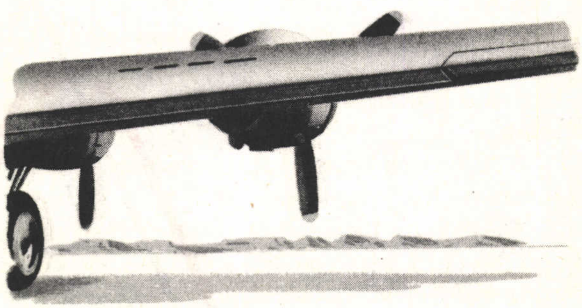
Check No. 3 turbo and exhaust

1. Check **turbo wheels:** Revolve them slowly by hand to observe clearance and freedom. Look for missing buckets and for cracks between buckets. Be sure the waste gate is fully open; check it for proper looseness or freedom of movement.

2. Check the **engine exhaust systems** for cracks or loose joints.

3. Check the **nacelle:** Look for loose fasteners or cowl flaps. Look for signs of oil leaks in the nacelle or on the engine.

Now repeat this inspection on No. 4. Then move to trailing edge of right wing.



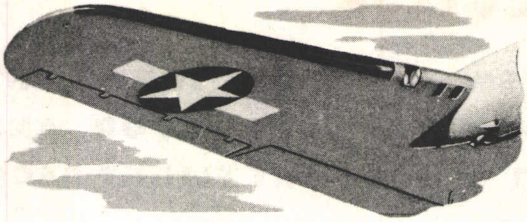
1. While passing under the wing, look for **loose inspection plates** and make sure that **drain plugs** are safety wired.

2. Check the **flap** for alignment, and for holes or dents.

3. Check **aileron surfaces** with controls in neutral. Apply pressure to the aileron to determine if controls are locked; check for excessive looseness.

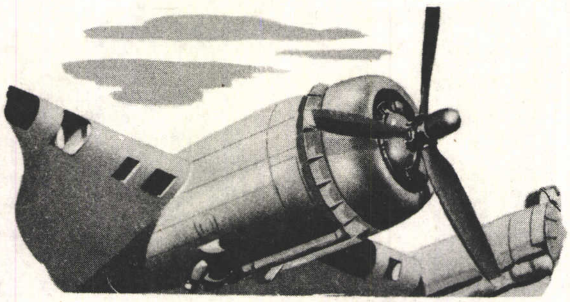
4. See that **external locks** are removed.

At right wing



1. Check the **de-icer boots:** Any torn or worn spots, any roughness of contour?
2. Check the **wing center section:** Any signs of fuel leaks? Are the oil and fuel caps secure, the gaskets in place?
3. Check the **air ducts:** Are they free of obstructions?

That brings you to power plant No. 4

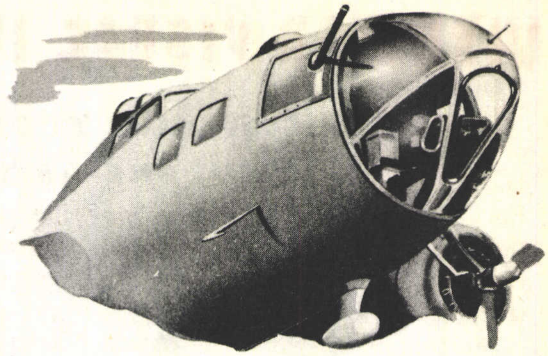


1. Check the **propeller blades:** Any nicks or cracks?
2. Check the propeller **anti-icer boots:** Look for looseness, for imbedded stones or cuts, for signs of leaking anti-icing fluid from the **slinger ring.**
3. Check the propeller **governor cables** for tautness.
4. Look for dirt, stones, or other foreign matter wedged between the cylinders or cooling fins. Stay clear of propellers.

Now follow the same procedure on power plant No. 3.

Inspect the Nose of the Airplane

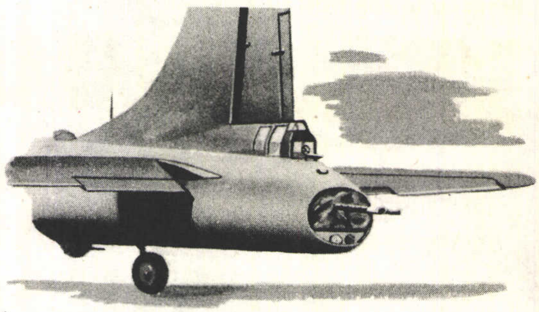
1. Check **pitot tubes:** Have the covers been removed?
2. Check the **antennae:** Are they in proper place and with leads connected? Is the trailing antenna retracted?
3. Check the **chin turret:** Be sure the guns are stowed and locked.



4. Check the **bomb bay tank vent** to see that the vent line protrudes through the bomb bay door and is not rubbing.

Now continue your inspection of the No. 2 and No. 1 power plants, left wing, aileron and tab, flap, No. 1 and No. 2 exhausts and turbos, left landing gear, and left side of fuselage.

Inspect the tail assembly



1. Check the **marker beacon antenna** on the airplane's belly between the main entrance door and ball turret.
2. Check the **de-icer boots.**
3. Check the condition of the **elevators** and **rudder;** check the **trim tab** alignment. Be sure **external locks** are not installed.
4. Apply pressure to **control surfaces** to determine whether they are locked or free.
5. Check the **tail gun assembly:** Are the guns locked in position? Is the tail gunner's escape door closed?

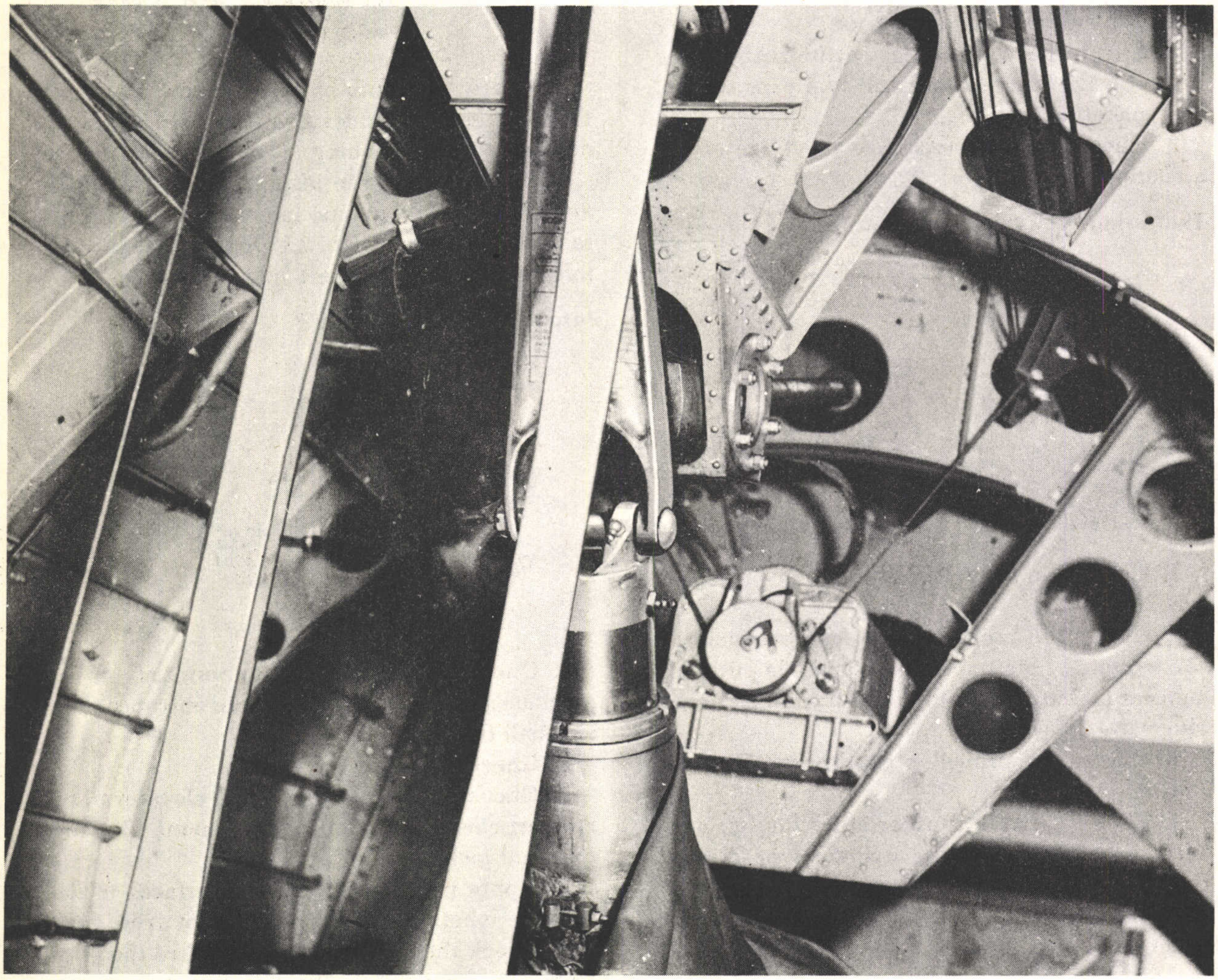
Inspect the tailwheel assembly

1. Check the **tire:** For inflation, for cuts, for excessive wear.
2. Check **shear pin and slot:** Be sure they are not worn or rounded.

You are now ready to enter the airplane.

INTERIOR VISUAL INSPECTION

CONTINUE YOUR SYSTEMATIC INSPECTION OF THE AIRPLANE AS YOU ENTER THE WAIST DOOR, AND BEFORE YOU PROCEED TOWARD THE FLIGHT DECK.

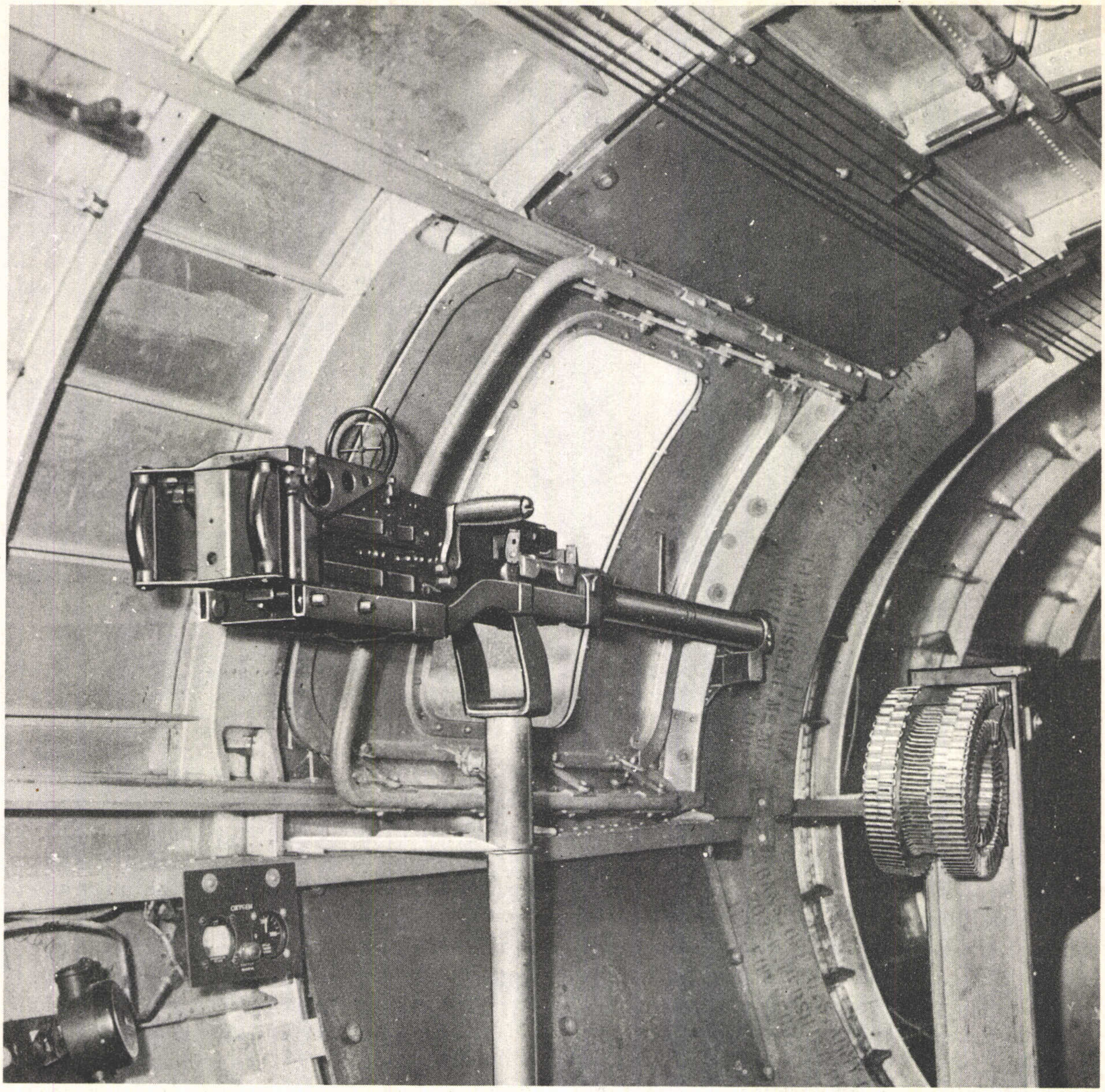


In the tail section

1. Check the **oleo** for the approximate clearance of 2⅝ inches.

2. Check the tailwheel yoke assembly, screw and entire assembly for alignment.

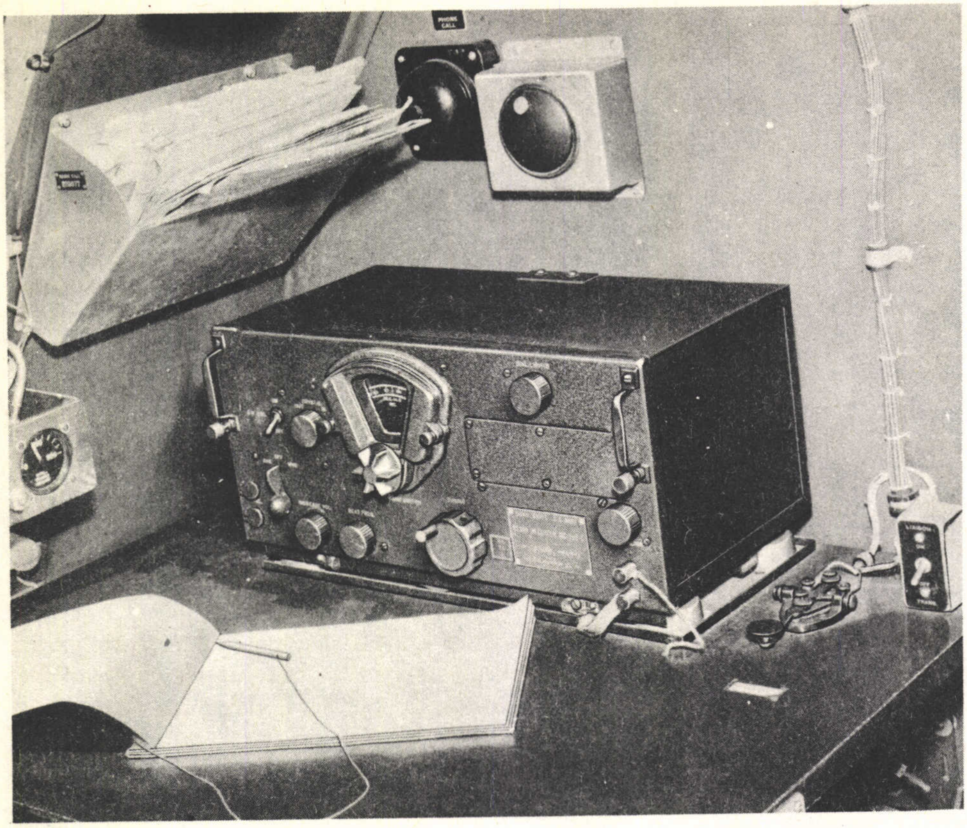
3. Make certain that no baggage or equipment is in the tail section.



In the waist section

1. Check **guns** for proper stowage.

2. Check **control cables.** Are they too tight, or too loose? Are they free from coat hangers, magazines, newspapers, miscellaneous articles that may have become wedged in among them? Loose small equipment must not be stowed in the rear of the airplane. Violent action in rough air may throw such articles into the control cables.



In the radio compartment

1. Stop and check your weight and balance data in Form F-AN 01-1B-40. (See pp. 198-202: Weight and Balance.)

2. Check **Forms 1 and 1A.** Watch particularly for the symbol that may appear under the heading "Status Today." **A red diagonal** means that the airplane is flyable, but is not in perfect condition; **a red cross** means that there is a major defect in equipment and the airplane must not be flown; **a red dash** indicates that the required inspection has not been made.

When maintenance personnel place a red symbol under this heading, they are fulfilling their responsibility to you and to the safety of your flight. It's up to you to investigate the significance of the warning symbol, learn the nature of the trouble, and govern your flight accordingly.

The meaning of the **red diagonal** will be stated clearly on Form 1A. Be sure you understand the exact nature of the defect indicated.

3. Check the fuel and oil servicing section of Form 1A and the amounts serviced.

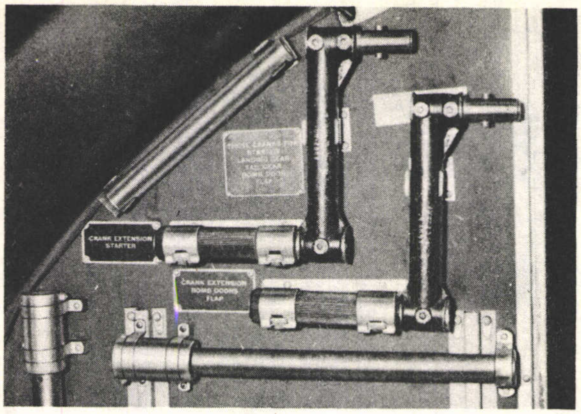
4. Pay particular attention to (a) the number of hours on each engine, (b) when the next inspection is due, (c) any notes that may have been entered by previous pilots or crew chiefs.

5. Check the **flight engineer's report** of preflight inspection. Discuss with the engineer any item that may indicate a questionable condition of the airplane or its equipment.

6. Make certain that the names of all crew members and passengers have been properly entered on the loading list. Sign the list and see that it is sent to Base Operations as required.

7. Ascertain that all on board are equipped with **parachutes,** that there is one extra parachute, and that this equipment is in proper condition. If an over-water flight is anticipated, make sure that all crew members have life vests.

8. Check **oxygen equipment:** The condition of masks, conditions of main oxygen system, the condition of walk-around bottles.



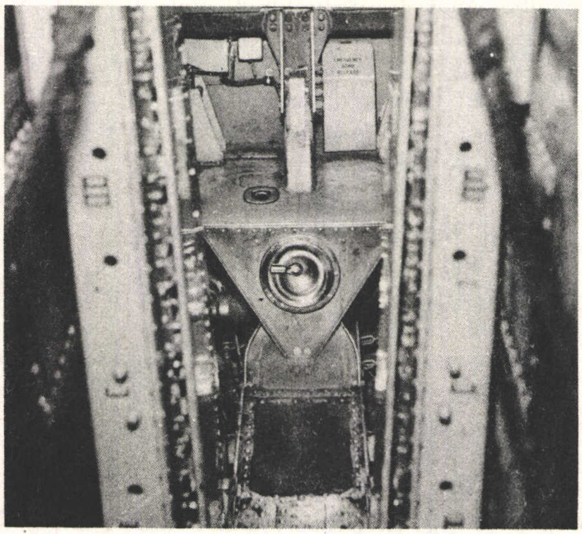
9. **Check the emergency landing gear hand crank:** Is it in proper place and locked?

10. Check **life raft emergency release handles** to be sure that they are properly set.

11. Check settings of the **command transmitter,** noting to what frequencies the transmitters are tuned.

12. Check Tokyo transfer valves for "CLOSED" position.

In the bomb bay section



1. Be sure the **bomb bay doors** are closed.

2. Check **bombs** or **racks** for proper installation.

3. Check the proper stowage of miscellaneous equipment.

4. If **bomb bay tanks** are installed, check the amount of fuel in each; be sure tank caps are properly secured, and rack selectors "OFF."

5. Check for excessive **gasoline fumes** in the bomb bay.

On the flight deck

1. Check the **upper turret:** switches "OFF," gun in aft position.

2. Check **fuel transfer valve and switch** in "OFF" position.

3. Examine floor and walls near the **hydraulic reservoir** for fluid leak. Check the **supply tank** for quantity of fluid.

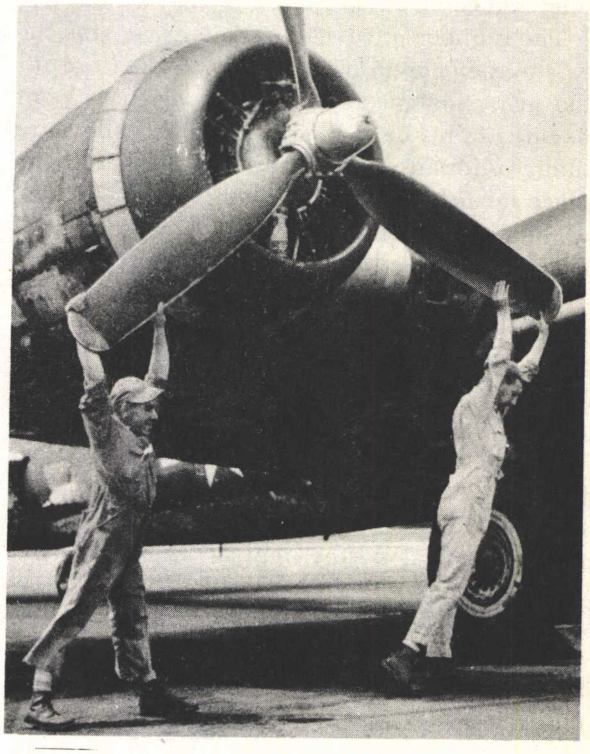
4. Be sure that up-to-date copies of all required maps, radio facility charts, instrument let-down procedures, radio navigational aids, and direction finding charts are aboard.

5. See that sufficient **first-aid packets** are aboard.

6. Check the number, condition, and location of **fire extinguishers** aboard.

7. Have the ground crew pull the propellers through at least three revolutions to clear the combustion chambers of the engines, after making sure that all ignition and battery switches are "OFF."

You are now ready to begin actual preflight operations according to the cockpit checklist.



Cockpit Checklist

Every B-17 has a checklist on the copilot's side of the cockpit. Individual sections of the cockpit checklist are described at length in the chapters that follow.

Bear this in mind: **It is absolutely essential that the cockpit checklist be used properly by pilot and copilot at all times.**

The number of procedures necessary for the safe and efficient operation of the B-17 are far too many for even the most experienced pilot to carry in his head. The best trained pilots are likely to forget things occasionally. **There is no place for forgetfulness in flying the B-17**! Your cockpit checklist is the only sure safeguard against it.

Proper use of the checklist requires a **definite procedure** and **active cooperation** between the pilot and copilot.

1. The copilot takes the checklist in his hand and, in a clear, loud voice, calls out each item.

2. The specific operation or check is then performed, either by pilot or copilot (as specified by the checklist), whereupon pilot or copilot repeats aloud the item as "Checked!"

For example:

Copilot: **"Gear switch . . ."**

The pilot places his hand on the landing gear switch and ascertains that it is in the neutral position.

Pilot: **"Gear switch neutral."**

Copilot: **"Intercoolers . . ."**

The intercooler controls are on a separate stand to the right of the copilot. Therefore, the copilot places his hand on the controls and makes sure that they are in the "COLD" position.

Copilot: **"Intercoolers cold."**

There are some duties which must be performed by both the pilot and copilot, as in the case of checking the fire guard and calling "Clear!" before starting engines.

The copilot, with checklist in hand, has the responsibility of seeing that no item on it is left unchecked inadvertently. He must keep his finger on each item as it is called aloud, and not move on to the next item until he has personally seen the pilot check the first item or checked it himself.

Practical necessity demands that a few portions of the checklist (such as After Takeoff, After Landing, Running Takeoff, Go-Around, Approach, Before Takeoff) be memorized by pilot and copilot, since both will be too busy during these operations to refer to the printed checklist. In such cases, the checklist is called aloud from memory; but both pilot and copilot have the same responsibility to see that the checks and double-checks are made.

STARTING

Your checklist becomes effective just as soon as you reach the airplane.

Pilot's Preflight

The duties under this heading—which began with your outside visual inspection of the airplane and continued as you passed through the interior from the rear section to the flight deck—have been completed.

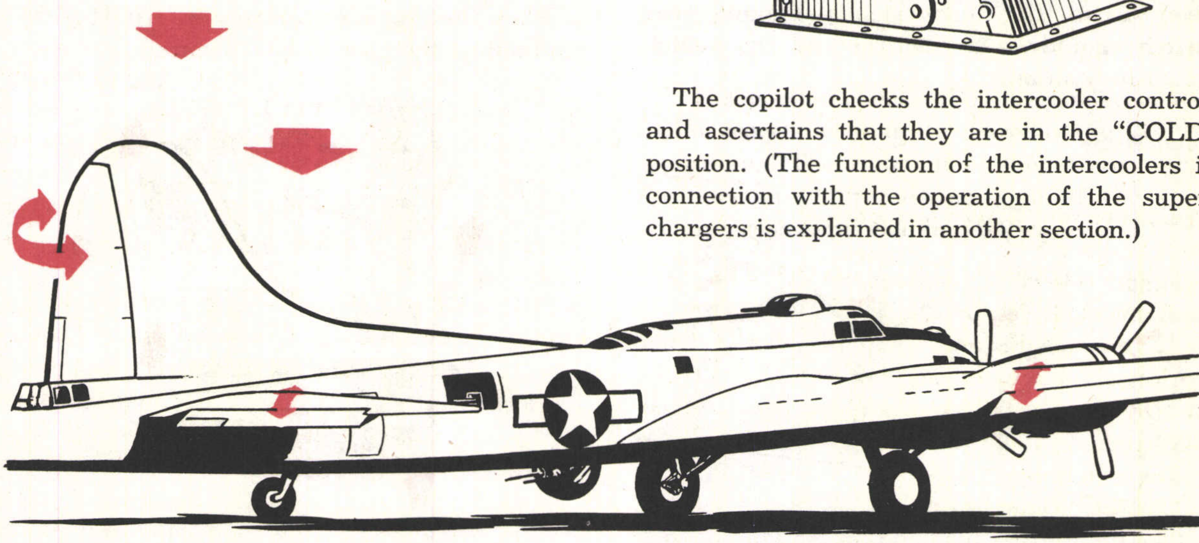
Form 1A

Form 1A was checked, completed, and signed after you inspected the radio compartment.

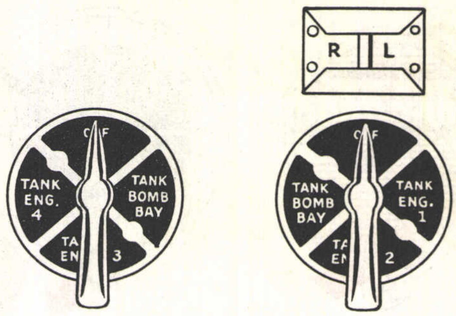
Controls and Seats

Unlock the controls, stowing the aileron locking pin on the clip on the control column. Check your controls visually—rudder, elevators, and ailerons. Put them through their full range of operation to insure freedom of movement and proper direction of operation.

Now both pilot and copilot adjust their seats, rudder pedals, and safety belts to insure freedom of movement and control through the full range of operation. Proper adjustment of these items is particularly important when the use of full rudder becomes necessary.

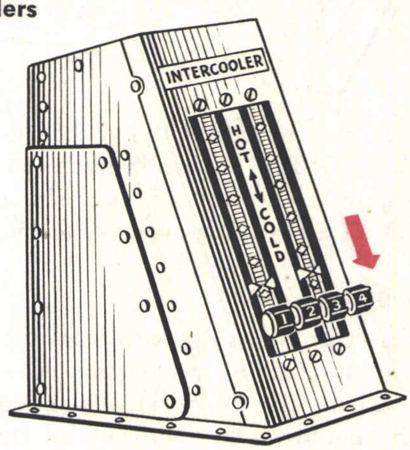


Fuel Transfer Valves and Switch



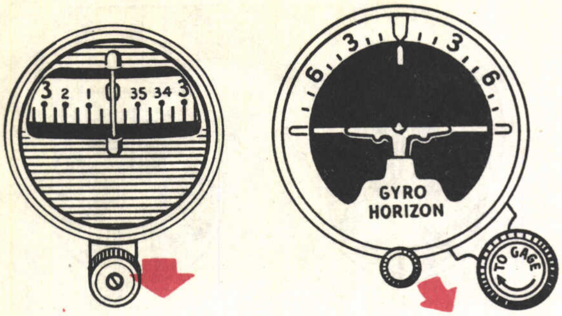
Check your fuel transfer valves and switch to be sure they are in the "OFF" position. Remember: if they are not turned "OFF," you may pump one of the engine tanks dry, and waste a lot of fuel from the overflow of the tank into which the gasoline is being pumped.

Intercoolers



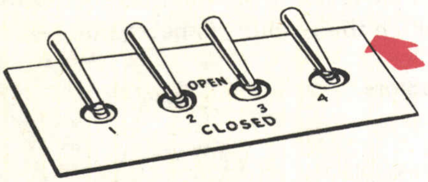
The copilot checks the intercooler controls and ascertains that they are in the "COLD" position. (The function of the intercoolers in connection with the operation of the superchargers is explained in another section.)

Gyros



Check your gyro instruments to be sure they are uncaged.

Fuel Shut-off Switches

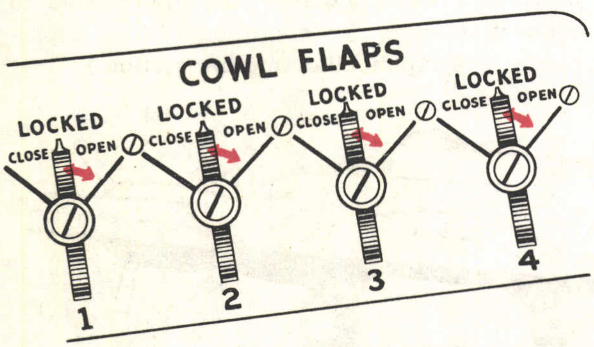


Check the fuel shut-off switches to be sure they are "OPEN." These switches control the fuel supply to the engines. They should be left open at all times except in emergencies.

Landing Gear Switch

Before turning on the battery switches, make sure that the landing gear toggle switch has not been turned "UP" inadvertently. **Landing gear switch should be at neutral and the switch guard in position.**

Cowl Flaps



Regardless of outside air temperature, the cowl flaps must be open before starting engines to avoid spot heating, and to allow the external fire extinguishers to be used effectively. Pilot and copilot check: "Cowl flaps open left"; cowl flaps open right!"–Locked." Cowl flap control levers should be placed in the "LOCKED" or neutral position after adjusting cowl flaps, to prevent creeping or loss of pressure.

Turbo-superchargers

Turbos are always turned "OFF" during starting. With the supercharger on, the waste gate is closed. A backfire could blow out the waste gate or damage the supercharger.

Idle Cut-off

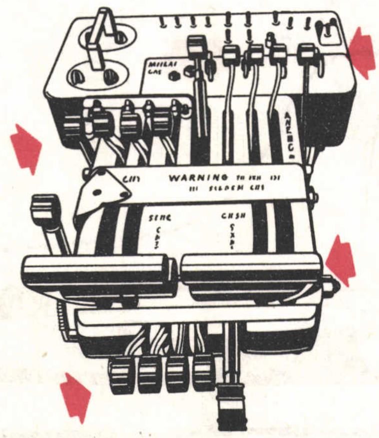
Check to insure that mixture controls are in the "IDLE CUT-OFF" position.

Throttles Closed

Close the throttles, then move them forward to the setting for approximately 1000 rpm (cracked). Engines will start much easier with throttles in this position. **After the engine has been started** and begins to run smoothly, set the throttles to hold 800-1000 rpm. Throttles should not be moved backward and forward (pumped) in an attempt to smooth out the engine. This results in a lean mixture, backfiring, and increased fire hazard.

High RPM

Place the propeller controls in "HIGH RPM" and adjust the lock to hold securely.

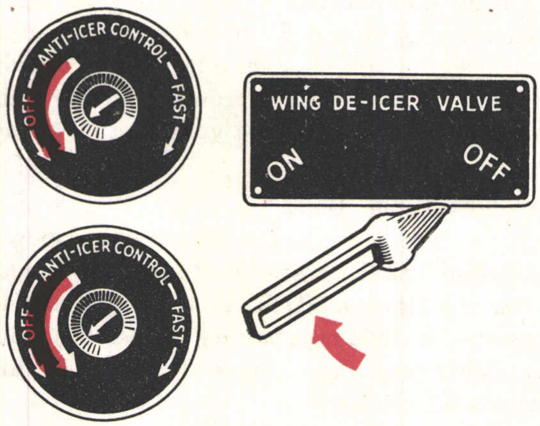


TURBO-SUPERCHARGERS OFF, PROPELLERS IN HIGH RPM, MIXTURE IN IDLE CUTOFF, THROTTLES CLOSED

Automatic Pilot

Place the automatic pilot switches in the "OFF" position and leave them there until after takeoff. Takeoffs with the automatic pilot on have resulted in accidents. Autopilot pressure is supposed to be low enough so that it can be overpowered by the manual controls, but on takeoff the busy pilot probably will be slow to recognize this condition and apply sufficient pressure on the controls quickly enough. So, before starting, check: **Autopilot**—"OFF."

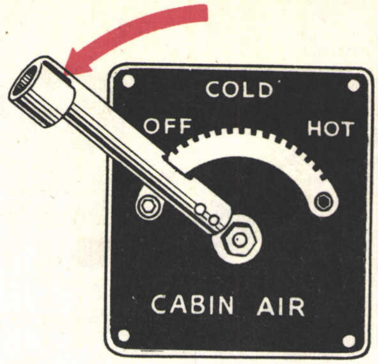
De-icers and Anti-icers



Place the wing de-icer control valve, and the propeller anti-icer knobs and control switch in the "OFF" position. Since the action of the wing de-icer boots disturbs the flow of air over the lifting surfaces and materially increases stalling speed, the wing de-icers are never used on takeoff. The propeller anti-icing fluid is not needed on takeoff since ice is unlikely to form quickly enough. (When flights are to be made into icing conditions, both these systems should be checked thoroughly prior to takeoff.)

Cabin Heat

If glycol heating system is installed put the cabin heat control (to left of pilot) in the "OFF" position and keep it there during all ground operations. This will allow an unrestricted flow of air through the heating system radiator, and tend to prevent boiling of the fluid. Use the glycol cabin heater only in the air.



If the airplane has engine exhaust hot air cabin heaters, the control handle (located in radio compartment) may be in any position.

Generators

Keep generators "OFF" before engines are started. If generators are to be used for ground operation they should be turned on after engines are running.

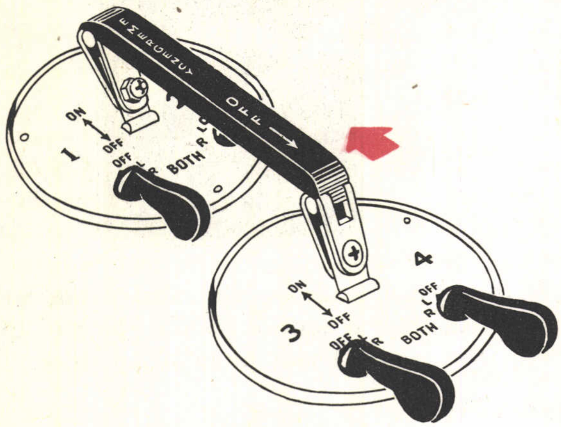
Check Fire Guard and Call "Clear"

Look out the window and be sure that the fire guard is posted at his proper station—behind and to the right of the engine being started.

The starting sequence is engines No. 1, No. 2, No. 3, No. 4. This sequence should be followed in order to avoid confusion of the ground crew.

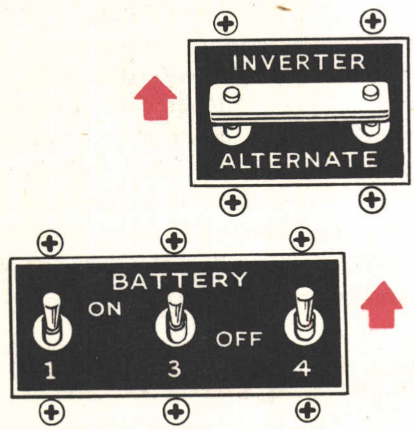
The pilot calls "Clear left," and the copilot calls "Clear right," before engines are started on either side. Both will make sure that the mechanic hears the call, and signifies (by voice or by hand signal) that all is clear.

Master Switch



Place the bar switch in the "ON" position. In some airplanes this switch cuts off only the ignition to all engines, but in most, the bar switch cuts off both ignition and batteries.

Battery Switches and Inverter



Move the inverter switch to "SPARE" (marked "ALTERNATE" in some airplanes) and turn on all three battery switches simultaneously. This prevents any one battery having to stand the heavy drain of starting the inverter, hydraulic pumps, etc.

With the inverter switch still on "SPARE" turn two battery switches off, so that a single battery is carrying the load. Then check the strength of that battery by listening to the sound of the inverter. Check other two batteries in the same manner.

After each battery has been checked, turn on all batteries and turn the inverter switch to "MAIN" (or "NORMAL") and leave it there during flight, keeping the spare new and unused for an emergency.

In late series airplanes a changeover relay automatically switches from main inverter to spare if the main inverter fails. It also lights a warning light ("push-to-test" type) on the control panel. This changeover relay will not switch from spare to main inverter, so always use main for normal operation.

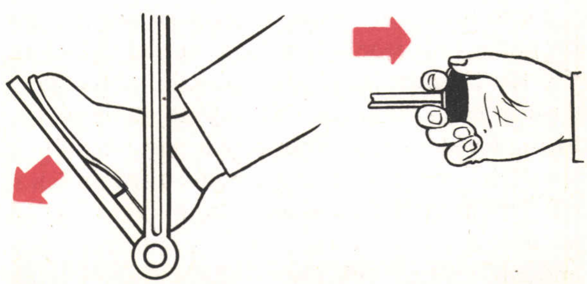
Alarm Bell

Check the alarm bell by flipping the toggle switch several times. If the bells are operating properly you will be able to hear them clearly. It is a good idea to have crewmen in the waist and tail sections report to you whether or not they can hear the bell.

Auxiliary Power Unit

If you are going to use the auxiliary power unit, signal to the crewmen that you are ready to have it started. NOTE: Always use external power (the APU or a battery cart) for starting whenever possible, to avoid depleting the airplane's batteries.

Hydraulic Parking Brakes and Check



Check the pressure gages for sufficient hydraulic pressure (600-800 lb.). Then check operation of the hydraulic pump by depressing the foot brakes several times to deplete the pressure in the reservoir. When pressure drops to 600 lb. the pump should cut in and build up pressure, cutting out at 800 lb.

Check the position of the toggle switch on the Pilot's Control Panel. It should be on "AUTO."

Copilot sets and locks the parking brakes as follows: (1) Depress the foot brakes fully; (2)

Pull out the parking brake knob; (3) Remove pressure from foot brakes; (4) Release the parking brake knob. If the parking brakes are properly set the foot brakes will remain partly depressed and the parking brake knob will remain partly extended.

After the brakes are set, look out at the wheel chocks to see that they are in place. They should be about two inches from the wheels so that they can be more easily removed by the ground crew.

Booster Pumps

Turn on the booster pumps and check to see that each gives from 6 to 13 lb. pressure. The fuel booster pump is an independent electrically driven source of extra fuel pressure. It takes the place of the wobble pump for both starting and emergencies, and augments the engine-driven fuel pump at high altitudes. As a safety measure, it is always turned on for takeoff and landing, for flights below 1000 feet, and for flights above 10,000 feet.

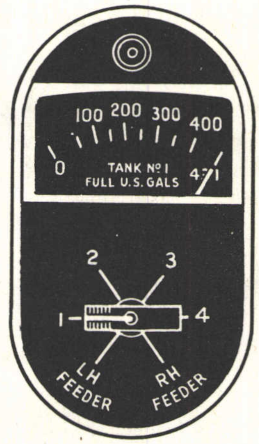
Carburetor Filters

Carburetor air filters must be "ON" ("OPEN") for engine starting and all operations up to 10,000 feet in the B-17F and 15,000 feet in the B-17G. Check amber warning lights for "ON."

In dust conditions filters may be left "ON" in the B-17F up to 15,000 feet (20,000 feet in the B-17G).

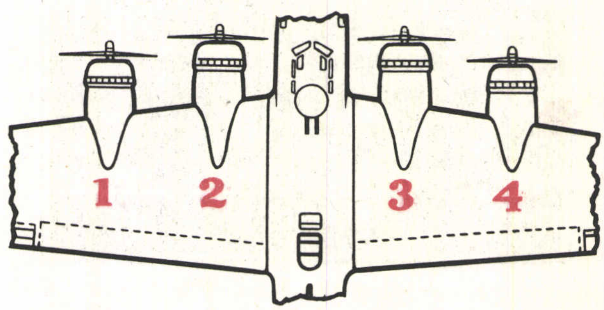
But under no circumstances should the carburetor air filters be left "ON" above these limits. When intake air passes through the carburetor air filters at such altitude the turbosuperchargers must speed up to maintain desired manifold pressure. This can result in turbo overspeeding.

Fuel Quantity



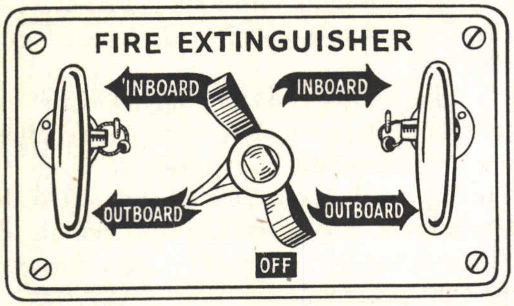
Check the fuel gages for quantity of fuel in each tank. Remember that the fuel gages are electric and will not operate unless the battery switches are on.

Start Engines



1. The sequence of starting engines is: No. 1, No. 2, No. 3, and No. 4.

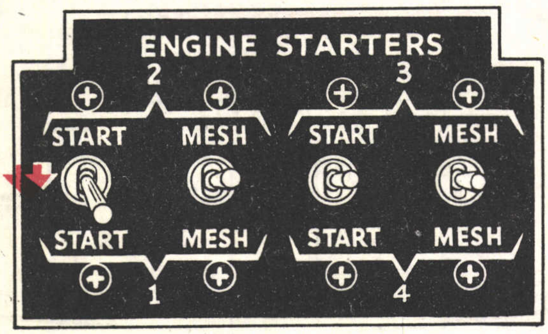
2. Be sure the engine being started has been pulled through 3 or 4 complete revolutions (9 blades).



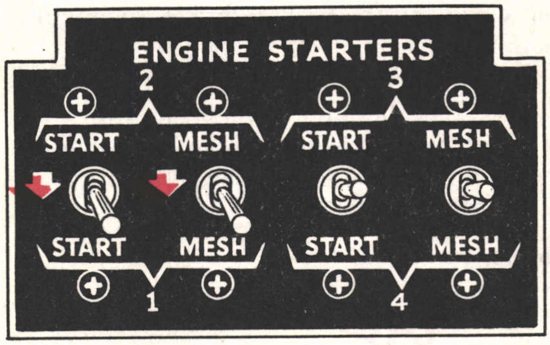
3. If fire extinguisher system is installed, set the selector switch to the engine being started.

4. Indicate to the ground crew (by holding up fingers) which engine is being started.

5. When the copilot is ready, he will notify the pilot: "Standing by to start No. 1."



6. Direct the copilot: "Start No. 1." The copilot will then energize Engine No. 1, and at the same time expel all air from the primer with the number of strokes necessary to obtain a solid fuel charge. The primer must be **held down** until needed again.



7. After approximately 12 seconds of energizing, direct the copilot to "Mesh No. 1." The copilot, while still holding the starting switch at "START," moves mesh switch to the "MESH" position. At the same time he primes with strong, steady strokes, if necessary, until the engine fires. When the propeller rotates once, turn ignition to "BOTH."

8. If the engine fails to fire after the starter has turned it over 4 or 5 times, the copilot must release both switches quickly while the propeller is still turning. This prevents damage to, or sticking of, the starter. If the starter dog sticks and the engine turns over while re-energizing, stop re-energizing immediately, cut the ignition switch, and release the starter dog by having the propeller turned by hand in the direction of rotation.

9. When the engine fires, move the mixture control to "AUTO-RICH" immediately.

10. If the engine stops, return the mixture control to "OFF" immediately, and repeat the starting procedure. As soon as engine is running, copilot calls: "Oil pressure." Pilot notes pressure, and responds: "Coming up" when pressure shows a steady rise.

11. If no oil pressure is indicated within 30 seconds after starting, stop the engine and determine the cause.

12. Warm up engines at 1000 rpm until oil temperature of 40°C is indicated.

13. If it is necessary to engage by hand, signal to the ground crew by raising a clenched fist

and pulling down an imaginary starter handle. One of the ground crew will pull the handle on the nacelle. Meanwhile, hold down both the starter and the mesh switches in the "ON" positions. The booster coil, or induction vibrator will function only when the mesh switch is on.

14. Repeat the same starting procedure on No. 2, No. 3, and No. 4 engines, in that order.

Generators

Turn generators on if they are to be used for ground operation.

Flight Indicator and Vacuum Pressures

After the engines are running check the vacuum pressures on the gage (approximately 4"). Turn the vacuum selector to each pump in turn to make sure that both are operating properly.

With vacuum pumps operating the flight indicator should erect itself within a few seconds. Sluggish response at this time indicates poor operation of the instrument.

(**Note:** If Jack and Heintz flight indicator is installed, it must be erected with the caging knob.)

Radio

Set the switches on the command receiver to proper positions. Turn the transmitter switch "ON." Set the selector to the desired transmitting frequency. Turn volume controls on jackboxes to maximum output. Set the selector switch on filter box to "VOICE," and selector switch on the jackbox to "COMMAND."

Check Instruments

Check instruments for

(1) proper operation

(2) readings within the proper range

OIL PRESSURE

Desired	70 lb.
Maximum	85 lb.
Minimum	50 lb.

OIL TEMPERATURE

Desired	70°C.
Maximum	88°C.
Minimum	60°C.

CYLINDER-HEAD TEMPERATURE

Desired	170°C.
Maximum	232°C.
Minimum	125°C.

FUEL PRESSURE

Desired	16-18 lb.

CARBURETOR AIR TEMPERATURE

Maximum	38°C.

FREE AIR TEMPERATURE

Does gage register approximate outside temperature?

TACHOMETERS

Steady indication

MANIFOLD PRESSURES

Steady indication

HYDRAULIC PRESSURES

Desired	600-800 lb.

CLOCK

Check and set

MAGNETIC COMPASS

Is the float level?

FLAP POSITION INDICATOR

Check for operation

Check Lights

If the flight is to extend after dark, check all other lights for proper functioning: landing, passing, wingtip, fluorescent, compartment, radio compass, and identification lights. A flashlight, in good working order, should be carried.

Check fuse panel covers for adequate supply of extra fuses.

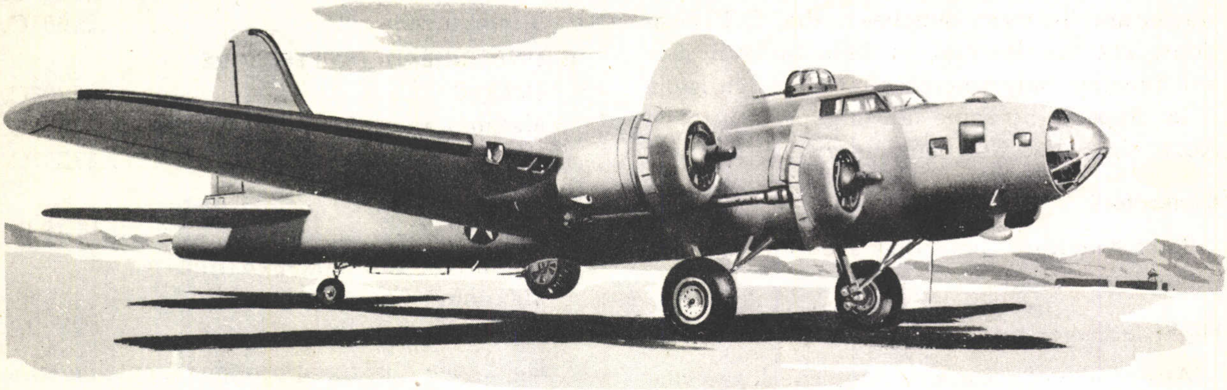
Crew Report

Check the crew to make sure that all doors and hatches are closed, and that all crew members are at proper stations, **with headsets on.**

Radio Call and Altimeter Setting

Call the tower for clearance, and obtain altimeter setting. Set and check the altimeter. If the setting varies more than 75 feet from field elevation, ask for another check.

TAXIING



There is only one reason for a taxiing accident: carelessness. The pilot who taxies slowly and observes the few basic rules will never have the inexcusable experience of damaging an airplane in simple ground operation.

The pilot experienced on heavier types of aircraft should understand the reasons for taxiing slowly. Primarily they are safety considerations, and the mechanical limitations of the brakes.

Safety considerations are so obvious that they need little explanation. The pilot who taxies slowly **always has control of the airplane** and can stop whenever and wherever he chooses.

The mechanical limitations of brakes make slow taxiing mandatory. You can't stop 50,000 lb. of fast-moving airplane in a short space. It takes tremendous frictional energy to slow down and stop this large mass. Moreover, frequent application of brakes, which is necessary when the airplane is not taxied slowly, causes excessively high brake temperature and eventual brake failure.

1. Before wheel chocks are removed, check hydraulic pressure: it should be 600 to 800 lb. Make sure the hydraulic pump is operating and the switch is in "AUTO."

2. Taxi from the parking area **with all 4 engines running,** using the outboard engines for turning. Keep your inboard engines idling at not less than 500 rpm, with just enough friction lock applied to prevent the throttles from creeping. Don't lock the throttles of the inboard engines tightly; you may need them in an emergency. Keep turbo controls off.

3. **Never taxi faster than a ground crew man can walk.**

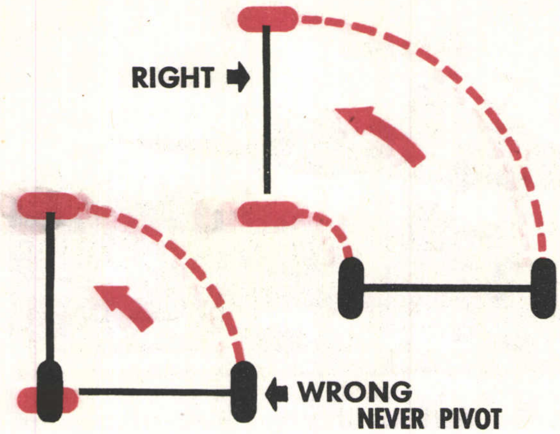
4. Use brakes only to slow down or stop the airplane, or to aid in making turns, when necessary. At all other times, keep your feet off the brake pedals with your heels on the floor. Even slight pressure will result in brake heating. When it becomes necessary to use brakes, slide your feet up on the pedals until the balls of the feet are squarely on the brake controls. Apply brakes smoothly and firmly. (Don't pat the brakes.) As soon as the airplane is under control, release brakes and return heels to floor.

5. For all straight ahead taxiing—even for a short distance—keep the tailwheel locked.

6. Before making a turn, have the copilot unlock the tailwheel. Make turn by using the throttles, with as little brakes as possible.

7. Always make turns with the inside wheel rolling. Pivoting on the inside wheel causes excessive wear on the tire and places a heavy torque strain on the gear.

Use Brakes Sparingly



8. If a side wind blows the airplane off a straight line, wait until you reach the other side of the runway, then unlock the tailwheel and redirect the airplane, crabbing away from the windward side of the runway in a series of arcs or S's. (See cut.) Use the outboard engine on the side from which the wind is blowing to decrease the rapidity of your drift toward the windward side of the runway.

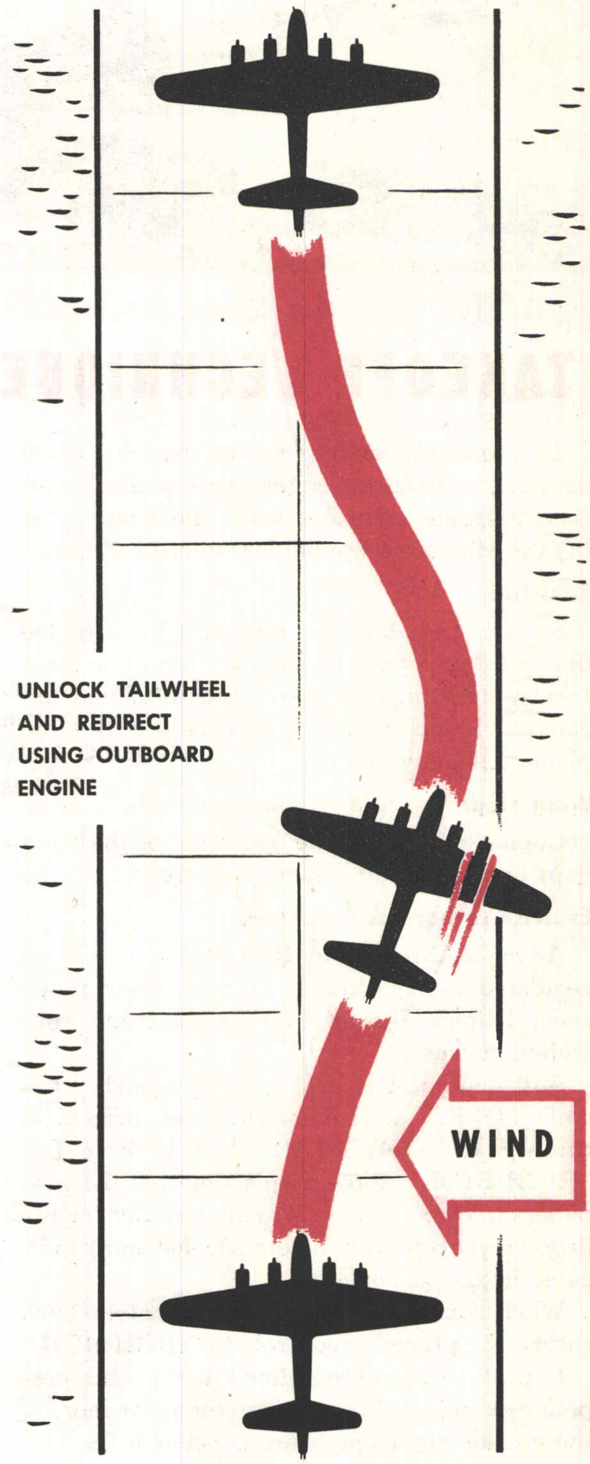
9. Hold the aileron and elevator controls in a neutral position, so that these control surfaces will be streamlined with wing surfaces and elevator stabilizers respectively. Don't try to taxi an airplane by steering with the control wheel as you would drive a car.

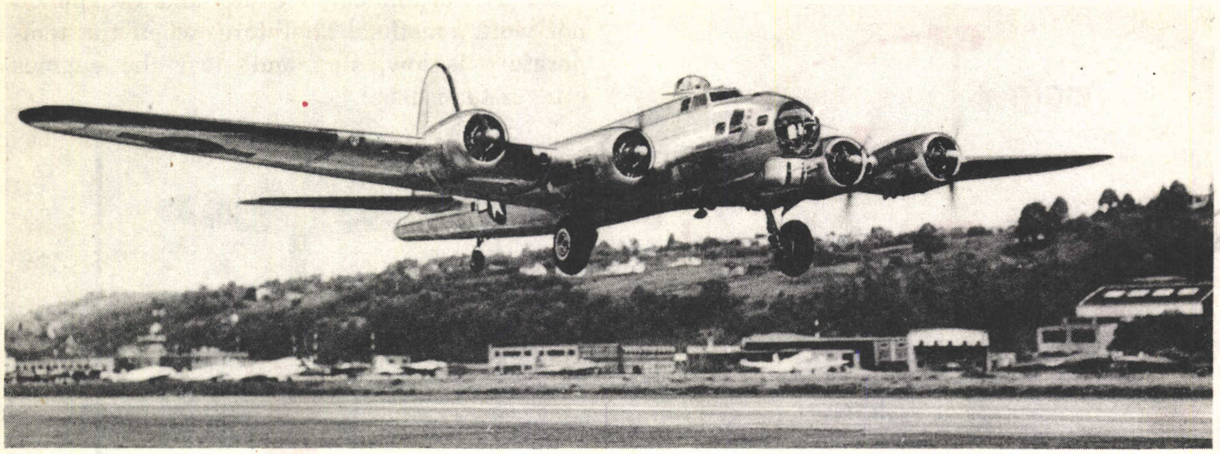
10. Take particular care never to allow the inboard engines to idle slowly enough to load up. During any one period of parking, don't permit them to idle at less than 1000 rpm. If you have to taxi over a long distance, stop and run up the engines high enough and often enough to keep them clear.

11. Don't try to taxi if hydraulic pressure is low and will not build up. (You will only lose what little pressure you have.) Have the airplane towed back to the line. **Check hydraulic pressure every 30 seconds. Copilot must be ready at all times to use the hand pump.**

12. Have your auxiliary power unit or generators turned on for all ground operations. This insures operation of the electrically operated hydraulic pump.

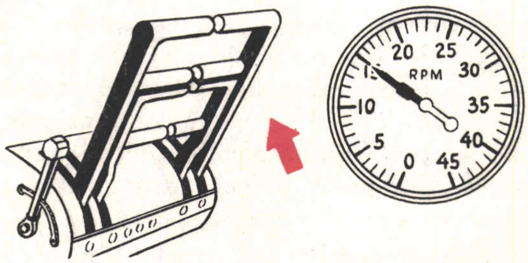
Remember that cold weather and low rpm do not work together. Therefore, when the temperature is low, stop and clear the engines oftener than usual.





TAKEOFF TECHNIQUE

Taxi to run-up area, park into the wind when possible, and call for engine run-up check. Copilot responds: "Brakes set." Make sure that the throttles are set at not less than 1000 rpm.

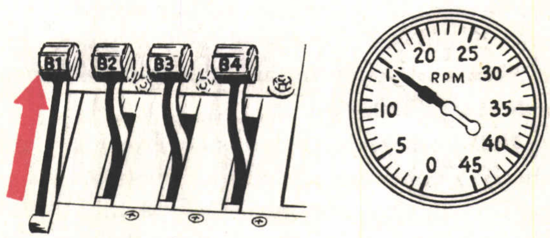


Trim Tabs

Set the trim tabs for takeoff. Check to see that all 3 tabs are at the "0" (zero) setting. Incorrect setting of any trim tab on takeoff can cause a serious accident, especially if the airplane is heavily loaded.

Wing Flaps

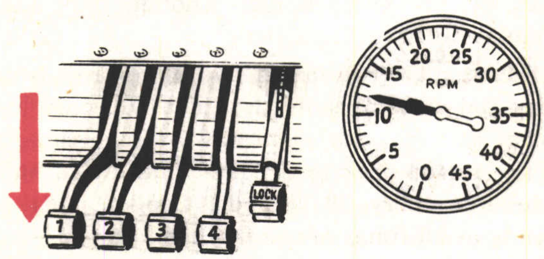
Copilot will check the operation of the wing flaps and make sure they are fully up.



Exercise Turbos and Propellers

Advance throttles to 1500 rpm and run oil regulated turbo controls through their range several times. **Do not exercise electronic controlled turbos.**

Still maintaining 1500 rpm, turn turbo controls "OFF," and then run the propellers through to "LOW RPM," then back to full "HIGH RPM." Allow ample time for the propellers to change pitch. Watch carefully for the drop in rpm (approximately 300-400 rpm) indicated by the tachometers.



When rpm decreases to approximately 1100, return the propeller controls to "HIGH RPM."

Repeat these oil regulated turbo and propeller exercises three or four times, or more if the outside air temperature is below 0°C.

Do not exercise turbos and propellers simultaneously.

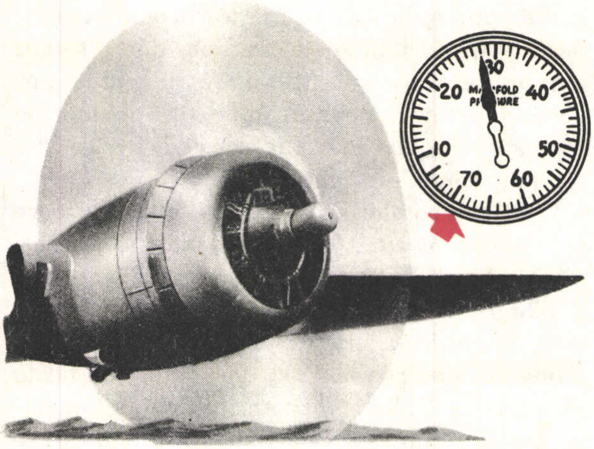
Check Generators

If the auxiliary power unit (APU) has been on, turn it off while checking generators, as generators cannot be checked with it on.

Check the generators while the engines are operating at 1500 rpm. Check them for ample output; and, by using the voltmeter selectors, check for voltage output.

With all generators on, check the pitot heaters by watching for a rise in the ammeter reading. Then turn the pitot heater off.

Run-up Procedure (Oil Regulated Turbos)



Run up engines in sequence: No. 1, No. 2, No. 3, No. 4.

1. Open throttle to 28″ manifold pressure. Then turn to left magneto, back to both, then to right magneto, then back to both. **Do not operate on one magneto for more than 5 seconds.**

The copilot watches for roughness of engine operation by observing any drop in rpm when running on one magneto. (A drop of 75 rpm is allowable.) The pilot watches the engine nacelle and cowling for visible indications of engine roughness. While the visual check of the nacelles and cowling is more reliable than the tachometer indication, utilize **both** methods as a double check. If much roughness is noticed on either magneto, run the engine up to full throttle **with turbo off** for about 10 seconds; then return to 28″ manifold pressure, and check again.

During the pilot's ignition check, the copilot will check the following items:

FUEL PRESSURE

Desired ....16 to 18 lb. sq. in.

OIL PRESSURE

Desired ....70 lb. sq. in.
Maximum ....85 lb. sq. in.
Minimum ....50 lb. sq. in.

OIL TEMPERATURE

Desired ....70°C.
Maximum ....88°C.
Minimum ....60°C.

CYLINDER HEAD TEMPERATURE

Maximum ....232°C.

2. After checking magnetos, run the throttle full forward, with turbo controls off and propellers in "HIGH RPM," and note manifold pressure. If the engine is operating normally it will develop about 37″ at sea level. Atmospheric conditions and wind may vary the manifold pressure from day to day, but if one engine develops considerably more or less manifold pressure than the others, a faulty engine is indicated.

3. Throttle back to 28″ Hg. and move turbo control full forward against the stop.

4. Wait for increased manifold pressure (usually about 5-8″ Hg. surge). This indicates that turbo wheel is turning up to speed.

5. Run throttle forward and adjust turbo to give desired takeoff setting.

Remember that because of direct linkage control, the waste gate will open immediately when turbo control is moved toward closed position, and will lag when moved forward. Therefore, care should be exercised in adjusting control so that excessive full throttle operation is avoided on the ground.

Check rpm with full throttle and turbos set. Normally, for ground operation, rpm between 2400 and 2500 is satisfactory.

Reduce throttle to 1000 rpm.

Repeat the foregoing run-up procedure on engines No. 2, No. 3 and No. 4 in sequence.

Run-up Procedure (Electronic Turbo Control)

1. Run up engine No. 1 to 28″ manifold pressure, and check the magnetos.

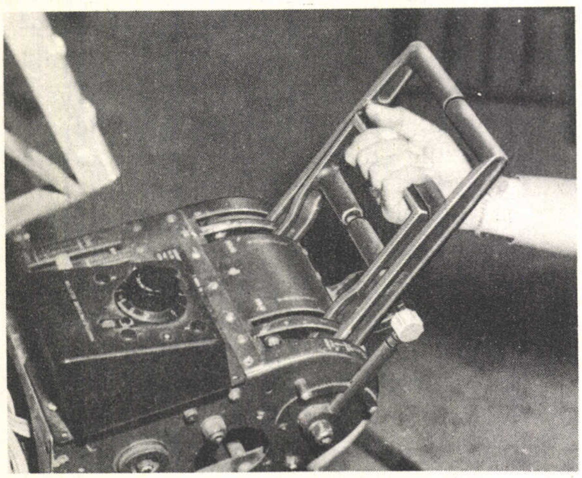
2. Open No. 1 engine to full throttle momentarily with the turbo boost selector on zero and note manifold pressure. It should be about 37″ Hg. at sea level.

3. Reduce No. 1 engine to 1000 rpm.

Repeat on No. 2, No. 3 and No. 4 engines.

4. After running up No. 4 engine, retard throttle to 1500 rpm, make sure No. 4 generator is on, and turn turbo boost selector to desired manifold pressure. Advance No. 1 to full throttle to check manifold pressure and rpm. Retard No. 1, and repeat on No. 2, No. 3, and No. 4. When retarding No. 4, turn off generators, unless they are to be used in further ground operations.

THROTTLE TECHNIQUE



The most comfortable and effective way to handle the throttles of the B-17 for operation of all 4 engines is to hold the **right hand palm upward,** thus grasping all 4 throttle handles firmly within the palm and fingers. (See cut.)

Holding them in this manner permits an easy wrist movement for **progressively** leading and controlling the throttles, and tends to favor the inboard throttles.

Progressively leading the throttles means alternately advancing right and left engines—in other words, **walking the throttles** steadily forward.

Adjustment of the throttle friction lock should be just enough to prevent the throttles from creeping. Don't jam the lock lever hard forward; you'll only have to struggle to loosen the lock each time you want to change throttle settings. Friction should be such that (1) throttle creeping is prevented, and (2) the throttle can be moved without too much pressure in case of emergency.

Before Takeoff

After engine run-up has been completed, make your radio call to the tower and request permission to taxi to takeoff position. Do not taxi on the runway until this radio contact has been completed. Bear in mind that it may be necessary for the tower to respond by using a red or green Aldis light.

Pilot and copilot should check visually to be sure the runway is clear and that no aircraft are landing. The tower is not infallible.

When cleared by the tower, instruct the copilot to unlock brakes. Then, with engines idling at not less than 800-1000 rpm, taxi on to the runway. Take a position that will allow use of the full runway. See that all windows are closed and locked. Cowl flaps must be left open on takeoff. Call for takeoff check. Turn on booster pumps.

See that the airplane is lined up properly with the runway. Instruct the copilot to "Lock tailwheel." The copilot will lock the tailwheel as the airplane is slowly rolling forward, and will inform you: "Tailwheel locked; light out—Gyros."

Check the gyros. Set the directional gyro to correspond with the magnetic compass. When lined up for takeoff, check your compass reading with the runway heading. Pilot responds: "Gyros set."

Copilot calls: "Generators" as throttles are advanced for takeoff. When 1500 rpm is reached, pilot turns on generators with left hand. If generators have been on for ground operation, pilot checks generator switches.

TAKEOFF

Duties of the pilot, copilot, and flight engineer on takeoff are well defined. Each has specific duties to perform, and it is important that all three should have an over-all understanding of the takeoff procedure.

1. Apply power gradually, **progressively leading the throttles.** Avoid **over-control,** which will require reduction of power on either side.

2. Keep your right hand on the throttles.

3. During the takeoff run, maintain directional control with rudder and throttles. **Keep ailerons neutral.**

4. Always take off from a 2-point, tail-low attitude. (The 3-point takeoff should never be attempted except in an emergency.) Don't attempt to pull the airplane into the air. Normally when you have attained an airspeed of approximately 110-115 mph, moderate back pressure on the control column will enable the airplane to fly itself off the ground.

5. The copilot follows through on the throttles, keeping his left hand in position to make adjustments for variations in manifold pressure, and prepared to take immediate action in such emergencies as runway propellers or overspeeding turbos.

6. The copilot's principal duty on takeoff is to watch the engine instruments, particularly manifold pressure, rpm, pressure gages, and temperature gages. He must divide his attention between engine instruments and the actual progress of the takeoff.

7. Takeoff distances for various field conditions and airplane loading are stated specifically on the seat-back operating instructions and in AN 01-20EF-1 and AN 01-20EG-1.

8. After the airplane has left the ground, and you are positive that you have sufficient flying speed and that everything is under control, signal to the copilot to raise the landing gear. The copilot will apply brakes gently to stop the rotation of the wheels, and raise the gear. Both pilot and copilot make a visual check, and acknowledge the retraction of the main wheels (Pilot: "Landing gear up left." Copilot: "Landing gear up right." The flight engineer checks and reports "Tailwheel up.") The copilot places the landing gear switch in the neutral position.

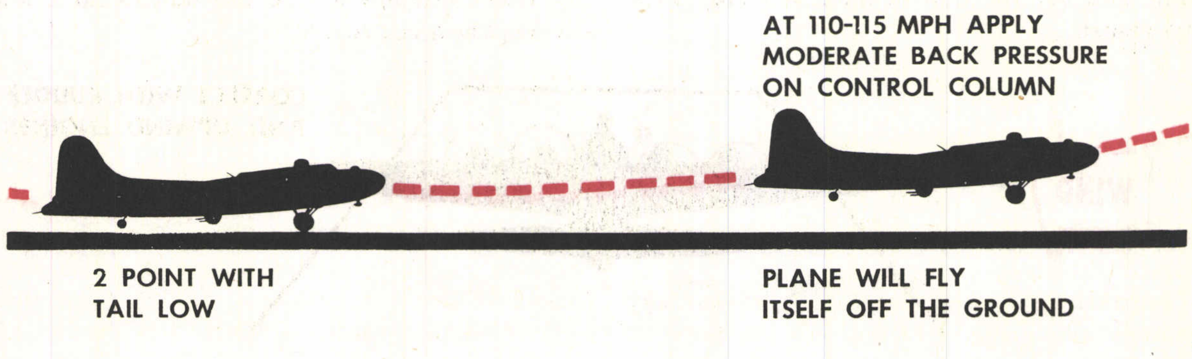
9. The B-17 is so constructed that very little change in trim will be required after takeoff.

10. Depending upon elevation and gross load, signal the copilot either to reduce or shut off the turbos.

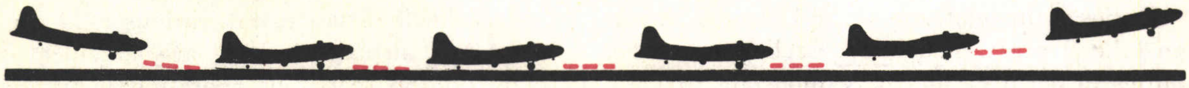
11. Reduce power upon attaining an airspeed of 140 mph. To obtain normal climb attitude, the pilot reduces the throttles to a manifold pressure between 32" and 35" Hg. in the transition type B-17, and 35" Hg. in the normally operated tactical airplane. Then the copilot reduces rpm to 2300.

12. The copilot will make the necessary adjustments of cowl flaps to regulate cylinder-head temperature during the climb.

13. Turn off booster pumps at safe altitude.



RUNNING TAKEOFF



This type of takeoff does not vary much in basic technique from the normal takeoff.

1. Make a normal 3-point landing.

2. When the airplane has settled into the landing roll, inform the copilot: "Running takeoff."

3. The copilot immediately checks propeller controls for "HIGH RPM," and places the flap switch in the "UP" position.

4. Now apply power, walking up throttles steadily and smoothly. Avoid abrupt throttle movement.

5. Use rudder for directional control. The airplane still has most of its landing speed when power is applied. If directional control is difficult before full power is attained, use coordinated throttle and rudder.

From this point forward, the operation is the same as a normal takeoff. Complete the usual after-takeoff check: (1) Signal copilot for "Wheels up" if leaving traffic; (2) reduce power; (3) adjust cowl flaps; (4) make check of "Wheels up right." "Wheels up left." Engineer: "Tailwheel up."

CROSSWIND TAKEOFF

The crosswind takeoff requires **use of more rudder** and more **differential throttling** than the normal takeoff.

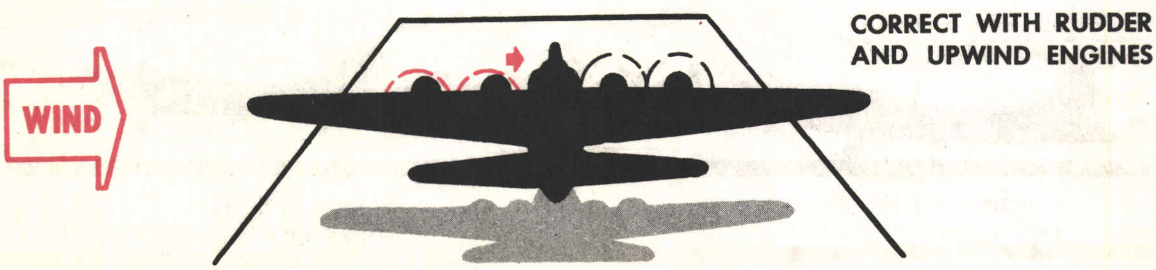
Most modern airfields are so constructed that there is seldom any occasion for taking off in an extreme crosswind. However, because the large vertical surfaces of the airplane are exposed to any wind from the side the airplane will tend to veer **into** the wind. Therefore, the technique of the crosswind takeoff is extremely important and frequently useful.

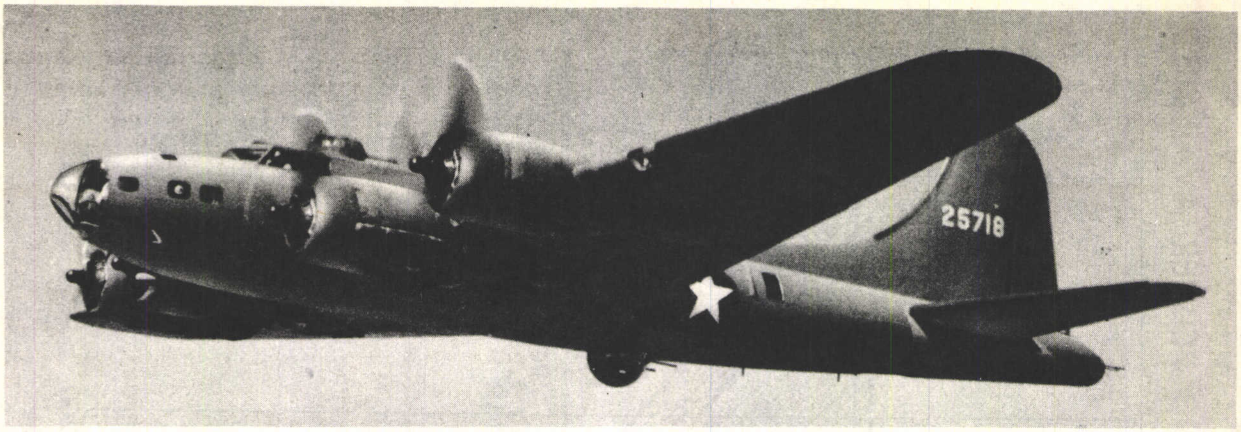
Remember that the important elements in the crosswind takeoff control, in order of importance, are: (1) rudder, (2) differential throttling, and (3) the downwind brake **only as a last resort.**

Use rudder to keep the airplane straight as long as possible. However, in a strong crosswind, if use of rudder is not sufficient to keep the airplane straight, apply more power to the upwind engines. Remember that progressive application of power (on all 4 engines) is necessary to attain takeoff speed as quickly as possible.

If the upwind engines have been used all the way to the stop and the rudder still will not straighten the airplane, **only then apply slight reduction of power on the downwind engines.** Under most crosswind conditions, this should not be necessary.

Don't attempt to use the downwind brake except as a last resort.





CLIMBING AND CRUISING

The rate at which an airplane will climb is obtained directly from the difference between the **power required for level flight** and the **power available** from the engines. This difference is the **reserve power** which can be used for climbing.

Climbing the B-17

Flight tests have shown that for B-17's of all weights, the difference between **power required** for level flight and **power available** reaches a maximum at approximately 135 mph IAS. For stability purposes, another 5 mph is added as a safety margin. Therefore, **make your climb at 140 mph IAS**, except on instruments.

Climbing on Instruments

On instruments below 20,000 feet, climb at 150 mph IAS. Here again an allowance has been made in the recommended airspeed for a safety margin.

Power Settings for Climbing

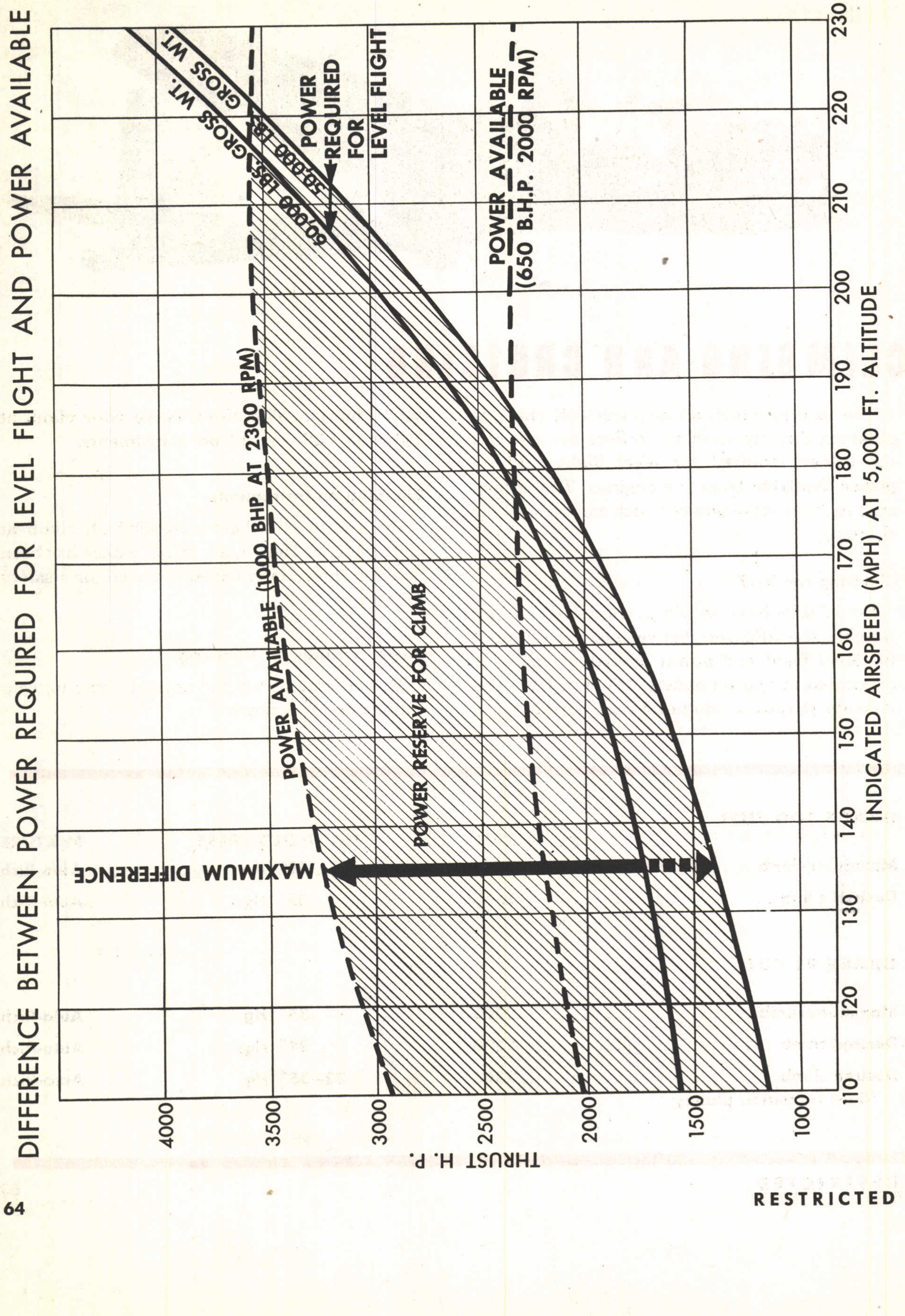
Power settings for the normal climbing conditions are as follows:

GRADE 100 FUEL

	RPM	MANIFOLD PRESS.	MIXTURE
Maximum climb	2300	38″ Hg.	Auto-Rich
Desired climb	2300	35″ Hg.	Auto-Rich

GRADE 91 FUEL

	RPM	MANIFOLD PRESS.	MIXTURE
Maximum climb	2300	35″ Hg.	Auto-Rich
Desired climb	2300	34″ Hg.	Auto-Rich
Desired climb (light transition planes)	2300	32—35″ Hg.	Auto-Rich


DIFFERENCE BETWEEN POWER REQUIRED FOR LEVEL FLIGHT AND POWER AVAILABLE
50,000 LBS. GROSS WT.
60,000 LBS. GROSS WT.
POWER REQUIRED FOR LEVEL FLIGHT
POWER AVAILABLE (650 B.H.P. 2000 RPM)
POWER AVAILABLE (1000 BHP AT 2300 RPM)
POWER RESERVE FOR CLIMB
MAXIMUM DIFFERENCE
THRUST H. P.
1000
1500
2000
2500
3000
3500
4000
INDICATED AIRSPEED (MPH) AT 5,000 FT. ALTITUDE
110
120
130
140
150
160
170
180
190
200
210
220
230

Angle of Climb

The proper angle of climb should be judged by airspeed, obstacles to be cleared, and the attitude of airplane. Trim the airplane to relieve control pressures, and synchronize propellers as soon as climbing power settings are established.

In B-17's with full crews, and with guns and turrets installed, with or without bomb load, 35" Hg. and 2300 rpm at 140 mph will give a desired attitude and rate of climb. However, in a transition airplane from which this equipment has been removed, this power setting for climbing may cause the airplane to assume a high climb attitude while maintaining 140 mph IAS. Take these things into consideration, and remember: the important thing is to maintain normal climbing attitude and airspeed.

Auto-rich for Climbs

For climbs leave mixture controls in auto-rich. At high power the proportion of fuel to air must be relatively high to assist in cooling and prevent detonation.

Effects of Increasing Altitude

As altitude increases:

1. Engines get hotter the longer they operate at climbing power, thereby increasing cylinder-head and oil temperatures.
2. IAS gradually falls; atmospheric pressure gradually decreases.
3. It becomes more difficult for man to obtain sufficient oxygen from the atmosphere.

Remember these conditions which develop with increasing altitude. Consider their effects on (a) your airplane, (b) your crew.

Engine Heat

1. **Cylinder-head Temperatures.** Adjust cowl flaps to maintain head temperatures about or below 205°C.

2. **Use of Cowl Flaps.** Keep in mind that the position of cowl flaps affects your rate of climb because of added drag and disturbance of the airflow. However, do not hesitate to use them to keep the cylinder-head temperatures within operating limits. Use the minimum setting that will maintain the temperatures desired.

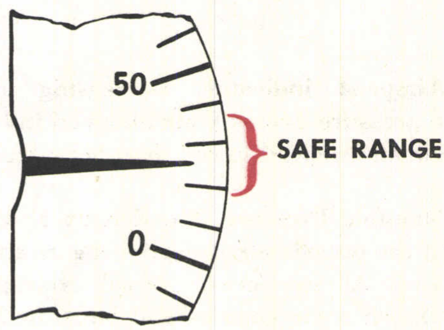
3. **Oil Temperatures.** Oil temperatures can be reduced more quickly by decreasing the engine rpm and manifold pressure than by reducing the throttles alone. Another way to reduce both cylinder-head and oil temperatures is to shallow your climb so that your IAS is 5 to 10 mph faster than normal climbing airspeed. This will not cause much loss in your rate of climb.

In case of high cylinder-head and oil temperatures that cannot be controlled by other means, you can use **emergency** (full) rich mixture. This will dissipate the heat rapidly, but will also cause loss of power and excessive gas consumption. Therefore, use it only long enough to reduce temperatures.

Decreasing Air Temperature

1. **Carburetor Air Temperature.** On an extended climb, check constantly to be sure your carburetor air temperature is either above or below the icing range: from $-5°C$ to $+20°C$. Particularly if the humidity is high, you can develop carburetor ice with little or no warning.

Carburetor temperatures above 38°C are likely to cause detonation. Control your carbu-



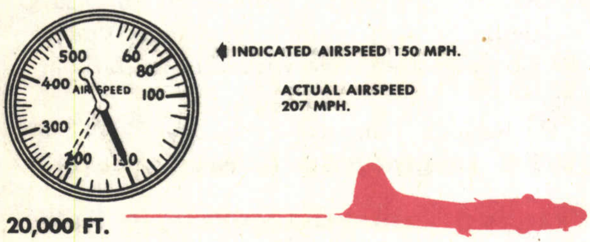
SAFE RULE:
KEEP THE CARBURETOR AIR TEMPERATURE ABOVE 20°C BUT NEVER ABOVE 38°C

retor air temperatures with your intercooler shutters and superchargers.

2. **Intercooler Shutters.** Hot compressed air is coming to your carburetor from the supercharger through the intercoolers. Intercoolers are kept in the "COLD" position to cool this compressed air. As you climb to higher altitudes it may be necessary to close these shutters to keep the carburetor air temperatures above the icing range. If you do close them, keep a close watch on both carburetor air temperatures and cylinder-head temperatures to be sure that the rise is not beyond limits. **Intercooler shutters should always be used with caution.**

3. **Heater.** Remember that there are crew members all over the airplane who may be getting cold. Ask them if they desire heat. The longer you can keep them warm the more effective they will be with their headwork, their bombs and their guns. Crew comfort is important to crew efficiency.

Decreasing Atmospheric Pressure



1. **Airspeed Indicator.** Decreasing atmospheric pressure causes your airspeed indicator to show an airspeed lower than your true airspeed.

2. **Manifold Pressure.** The density and pressure of the outside air is decreasing as altitude increases. At sea level, normal atmospheric pressure on some engines will be sufficient to maintain desired manifold pressure. As altitude increases and full throttles fail to give sufficient manifold pressure, you add boost with the turbo-superchargers.

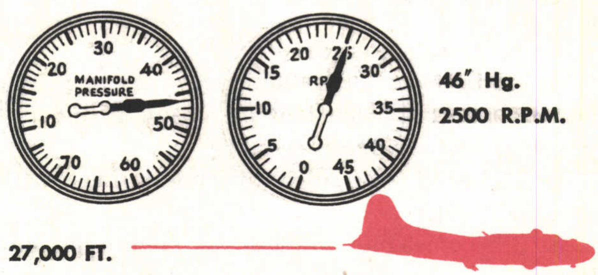
When climbing at a given throttle setting, rpm, and turbo regulator setting, the manifold pressure will increase slightly with altitude because the atmosphere has less back pressure effect in relation to the constant exhaust pressure. This results in a steady increase in turbo wheel speed.

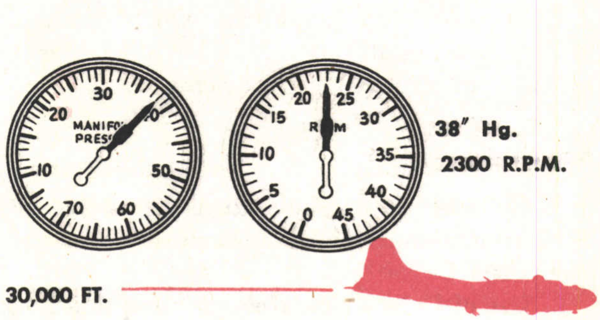
3. **Rules for Using Turbo-supercharger.**

a. Establish initial manifold pressure with full throttles. Get additional boost from turbo-superchargers.

b. Reduce manifold pressure by first reducing the turbo-supercharger regulators completely and then, if further reduction is necessary, reduce the throttles.

c. At altitude the turbo bucket wheel has a tendency to overspeed. (See section on Turbo-superchargers.) The critical altitude at maximum power setting of 46″ Hg. and 2500 rpm is 27,000 feet for the B-2 type turbo and 30,000 feet for the B-22 type. At a power setting of 38″ Hg. and 2300 rpm, the critical altitude is 30,000 feet for the B-2 and 34,000 for the B-22. Since you can tell which type of turbo is installed only by checking the records of the airplane or close examination of the turbo and nameplate, it is advisable to observe the lower B-2 limits.





MAXIMUM POWER SETTINGS
B-2 TURBO; GRADE 100 FUEL

Reduce the manifold pressure 1.5" Hg. for every 1000 feet climbed above the critical altitude. This means that when you are climbing at 38" Hg. and 2300 rpm, reduce 1.5" for every 1000 feet above 30,000.

While the electronic regulators are equipped with governors to prevent the turbos from overspeeding, the 1.5" Hg. for each 1000 feet should be taken off manually to prevent the governor from "hunting" and to prevent damage to the turbo if the governor is not operating properly.

4. **Booster Pumps on at 10,000 Feet.** As you climb and the atmospheric pressure decreases, there is more and more tendency for suction from your engine-driven fuel pump to cause vapor lock. Booster pumps put from 6 to 13 lb. additional pressure in the lines to offset this. **Turn the booster pumps on at 10,000 feet** and keep them on until you descend below that altitude.

5. **Crew.** As altitude increases your crew is becoming les efficient. Their ears tend to bother them. Head congestion may cause severe pain and they are getting insufficient oxygen. During day flights, go on oxygen between 7000 and 10,000 feet. At night, have the entire crew use oxygen from the ground up.

6. **Carburetor Air Filters.** Avoid use of carburetor air filters above 10,000 feet when climbing. Their operation above this altitude will cause rise in carburetor air temperatures, thereby increasing the possibility of detonation. In the B-17, filters must be closed above 15,000 feet. Failure to observe this precaution may cause detonation and eventual engine failure or sufficient overspeeding of the turbo wheel to cause serious damage. Remember also: use of filters reduces manifold pressure 1" to 2".

The Importance of Smooth Flying

Smooth, steady flying, proper trim, and minimum horsing of the airplane becomes more and more important to maximum performance as altitude increases. Steady, expert flying will cut fuel consumption, eliminate hazards, increase rate of climb, and reduce engine wear.

Remember that the only way you can maintain a constant altitude or climb and smooth, steady flying is with the aid of instruments.

SEQUENCE OF POWER CHANGES

The sequence of power changes for POWER INCREASE is first, mixture controls; second, propellers; third, throttles; last, superchargers.

1. **Mixture Controls:** At the pilot's signal, copilot sets mixture controls to "AUTO-RICH" if necessary. Maximum settings in "AUTO-LEAN" are prescribed for Grade 100 fuel (see Table of Power Settings). If power is increased to beyond these maximums, the mixture should be set in "AUTO-RICH" first.

2. **Propellers:** Copilot increases to desired setting. Propellers are set at desired rpm **before** increasing manifold pressure to eliminate the danger of an excessive BMEP (Brake Mean Effective Pressure).

3. **Throttles:** Pilot advances as rpm is increased. If more power than full throttle is required, advance the superchargers.

4. **Superchargers:** The oil-regulated supercharger controls may be advanced together, but it is advisable to set them one at a time, if operating with one or more engines dead. Always start with the dead engine side. Use full throttle before applying supercharger boost. If throttles are partially closed when turbos are in operation, the resulting back pressure will cause a power loss and possible detonation.

NOTE: *Move all controls slowly and smoothly*

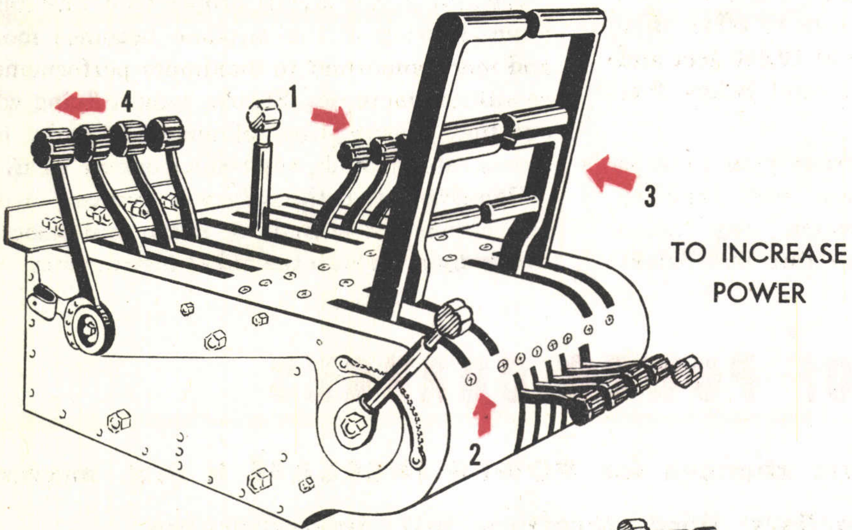
The Sequence of power changes for POWER REDUCTION is first, superchargers; second, throttles; third, propellers; last, mixture controls.

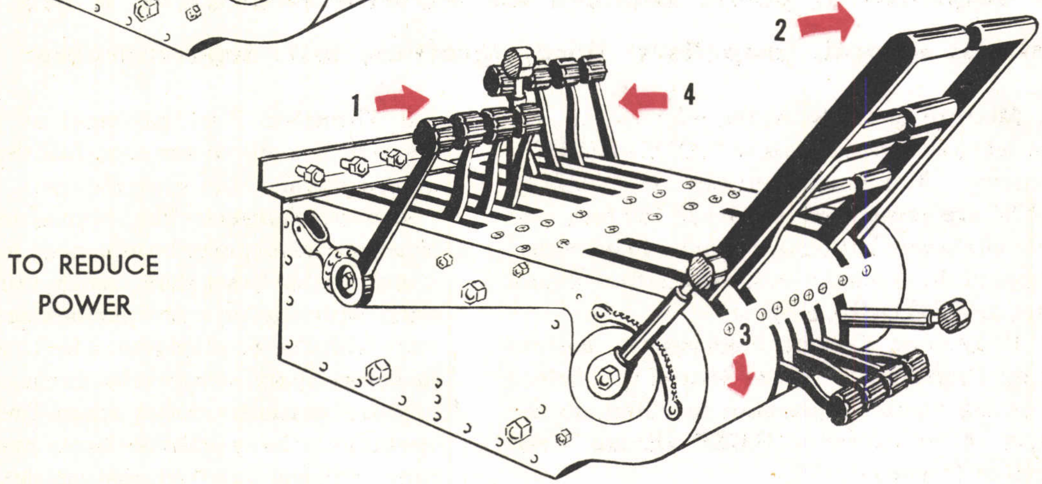
1. **Superchargers:** Pilot moves supercharger controls slowly. Retard superchargers before throttles to prevent back pressure in the carburetor.

2. **Throttles:** Pilot retards throttles. Reason: Manifold pressure must be reduced before propeller rpm in order to keep BMEP on the low side of normal. Although BMEP limits may not be exceeded for a particular case, it is advisable to always use the power sequence so that the pilot will instinctively follow this sequence in emergencies.

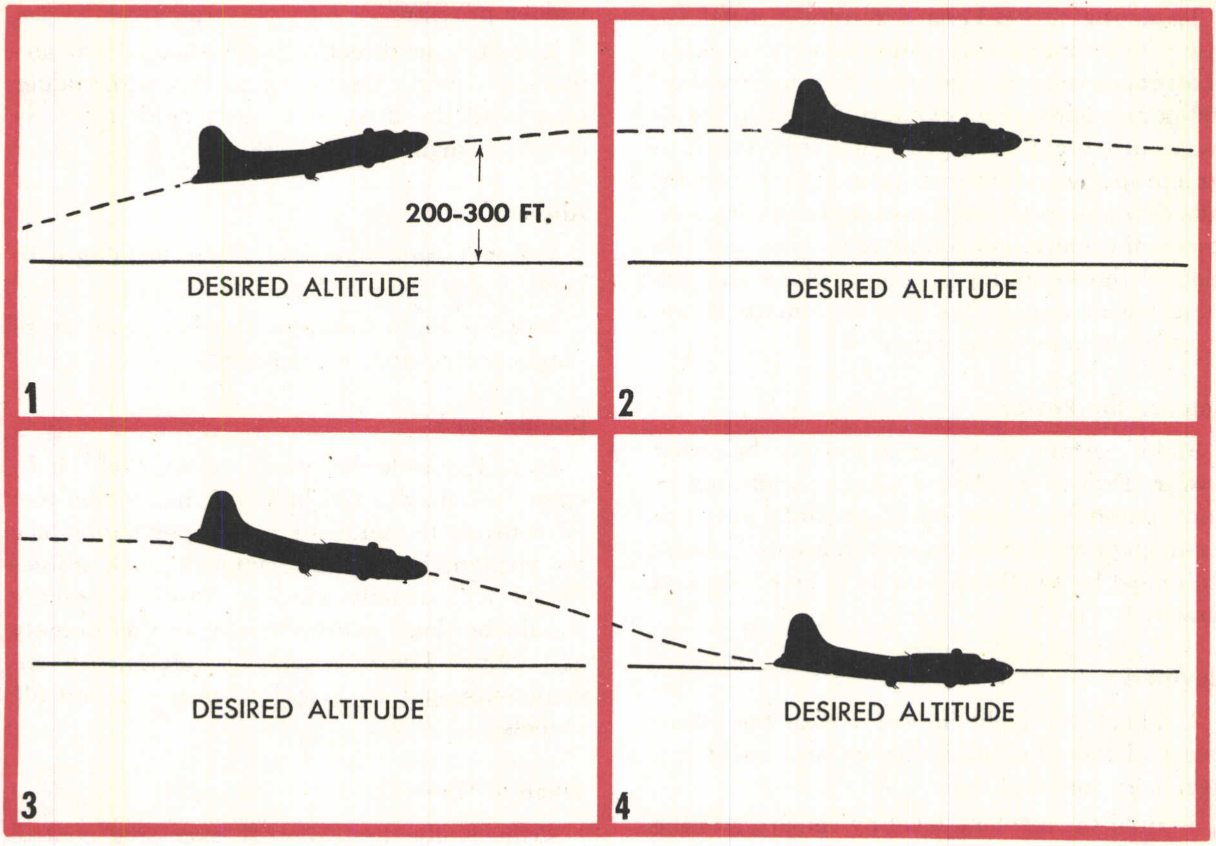
3. **Propellers:** Copilot decreases rpm at command of pilot. This must follow throttles to keep sequence in order, as explained above.

4. **Mixture Controls:** Copilot puts mixture controls in "AUTO-LEAN" if new power setting falls within limits.





LEVELING OFF



Always level off the cruising **from the top** in both speed and altitude. The purpose of this is to let the airplane build up full momentum for cruising. If you go directly from a climb to level flight and reduce power, the airplane will mush along at a high angle of attack and in a high drag attitude while trying to gain speed. It will fly sluggishly and inefficiently. The heavier your load, the more important it is to level off properly.

Leveling-off Procedure

1. Continue your climb to 200-300 feet above the desired cruising altitude.
2. Level off, drop the nose slightly to get on the step and pick up speed.
3. Reduce power to cruising setting and gradually descend to your cruising altitude.
4. Synchronize propellers and trim the airplane.

Cool Off the Engines

Remember that throughout the climb the engines have been generating heat. Give them a chance to cool down to slightly below desired cruising temperatures before you change to "AUTO-LEAN" mixtures. (See "Power Settings for Grade 100 and Grade 91 Fuel.") This allows the cylinders, blower and rear sections to dissipate heat. A well-cooled engine is less likely to detonate that a hot engine.

To aid cooling, don't close the cowl flaps immediately upon completing the climb. Instead close them progressively as airspeed builds up.

5

TRIMMING

Trimming the B-17 is a routine procedure, but it is tremendously important to the easy and proper operation of the airplane. Brawny, 200-pound pilots have exhausted themselves in one hour's flight merely because they failed to trim properly and frequently enough. Poor trim cuts down airspeed, increases fuel consumption, lowers the speed and ceiling of a climb, and decreases the efficiency of the airplane and the pilot. Formation flying is a nightmare if the airplane is improperly trimmed.

Balance the Power

Make certain that you are using **balanced power.** Propellers should all be synchronized and you should have equal manifold pressure on all engines. **This is important!** Manifold pressure must be equalized exactly to give balanced power.

Elevators

1. Check the flight indicator with the altimeter and rate of climb indicator, and re-set it if necessary for level flight.

2. Hold the airplane level by referring to the flight indicator. Adjust elevator trim to relieve any fore or aft pressure required to hold the airplane level.

Rudders

1. Hold the wings level with the ailerons by reference to the flight indicator and remove all rudder pressure.

2. Watch the directional gyro to see if the airplane is turning. Gradually correct with rudder trim until the directional gyro holds a steady course straight ahead.

Ailerons

1. Level the wings, hold a gyro heading with rudder, and release the wheel.

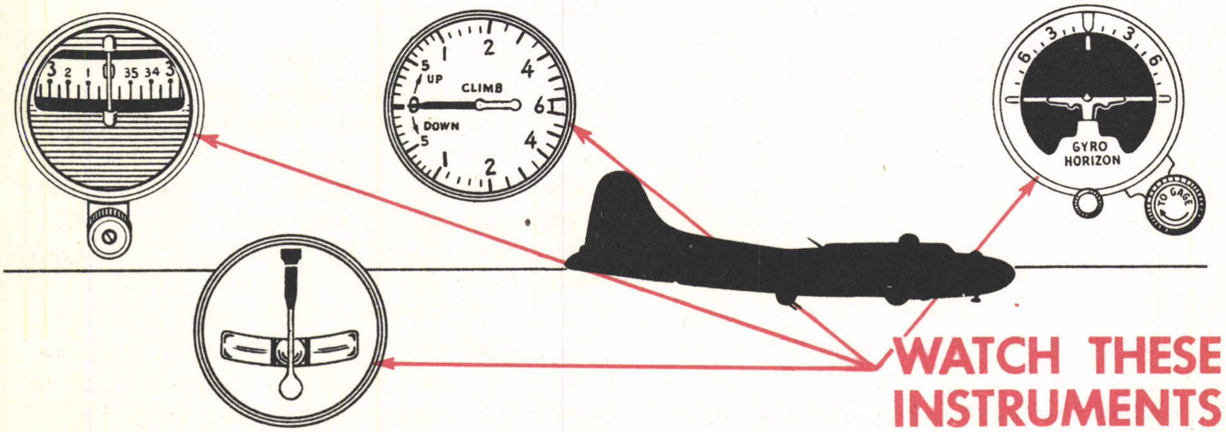
2. If the flight indicator shows a wing dropping, correct with aileron trim.

Double-check

Finally, check directional gyro, flight indicator, and needle and ball with hands and feet off controls to make sure of proper trim. Once the airplane is properly trimmed, small adjustments will usually keep it there. Trimming should be done automatically, and as quickly as possible. Learn to trim by reference to instruments, and by visual reference to outside objects.

When to Trim

Trim at the first sign of excessive control pressure. You will want to trim for climbs, descent, gear down or up, flaps down or up, when the crew changes positions, as fuel is used up, when bombs are dropped, in case of engine failure, when cowl flaps are changed, etc.



HOW TO SYNCHRONIZE PROPELLERS

The copilot brings propellers to desired tachometer setting with the propeller governor controls. Although rpm readings may be identical for all four engines, propellers may not be perfectly synchronized because of slight variations in tachometers.

Procedure for Synchronizing

1. To synchronize No. 1 and No. 2 propellers, leave No. 2 rpm unchanged. Have navigator or some crew member in the nose look at the propellers and report the direction of the **rotating shadow** (where the propellers appear to overlap). If the shadow is moving in the direction **opposite** to No. 1 propeller rotation, (up) that propeller is too slow and rpm should be increased. If the shadow is moving in the **same** direction as No. 1 propeller rotation, No. 1 propeller is too fast and should be decreased.

2. To synchronize No. 3 and No. 4, leave No. 3 rpm unchanged. If the shadow is moving in the direction **opposite** to No. 4 propeller rotation, the No. 4 propeller is too slow and rpm should be increased. If the shadow is moving in the same direction as No. 4 propeller rotation, it is too fast and should be decreased.

Check the Shadow

Remember that as seen from the pilot's seat all four propellers rotate to the right. Thus No. 1 turns toward you and No. 4 away from you. If the shadow rotates with the propeller, the propeller is too fast. If it rotates backward (against the propeller rotation) the propeller is too slow.

1. Make small adjustments with propeller controls. When propellers are synchronized, shadows will disappear.

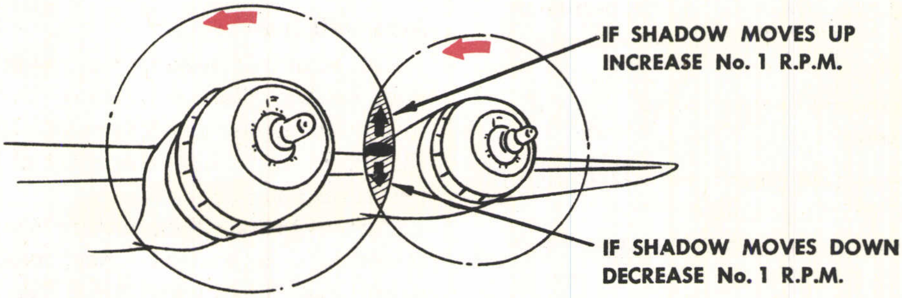
2. If shadows have disappeared and the engines still sound unsynchronized, (a distinct pulsation or engine beat) then the two propellers on one side are not synchronized with the two on the other side.

3. Synchronize left propellers with right propellers. Check the tachometers to see if either pair is indicating less than the desired rpm. If so, make small adjustments with the two propeller controls until you eliminate the beat and get a steady drone. If the beat gets worse, decrease rpm instead of increasing.

The difference in tachometer needle travel will indicate which governors are slow. With practice you will be able to lead with the controls for slow-acting governors and bring all four propellers to desired rpm simultaneously.

Synchronizing at Night

Use landing lights or flashlight to determine the rotation of shadows. With practice, you can complete the entire operation by sound.



Cruising

As soon as you have leveled off, synchronized propellers, trimmed the airplane, and let the engines cool down, check all instruments before going into "AUTO-LEAN."

Normal Pressures and Temperatures for Automatic Lean

1. Cylinder-head temperature: 232°C maximum; desired, 205°C or below.
2. Oil temperatures: 75°C desired; 88°C maximum.
3. Oil pressures: 70 to 80 lb. sq. in.
4. Fuel pressures: 16 to 18 lb. sq. in.
5. Carburetor air temperature: from 20°C to 38°C (under icing conditions).

Automatic Lean

If instrument readings are satisfactory, copilot (at the pilot's direction) moves the mixture controls one at a time to "AUTO-LEAN." Pilot and copilot note the effect of this on temperatures and pressures.

Carburetor air temperature should be kept below 38°C, as excessive heat may cause detonation. If an engine gets hot in "AUTO-LEAN" (a less cooling mixture) go to "AUTO-RICH" long enough to cool it down. If it stays hot in

"AUTO-LEAN," the automatic feature may not be operating properly, and you may have to use "AUTO-RICH" for that engine.

Booster Pumps

Remember to keep booster pumps on above 10,000 feet.

Superchargers

Low altitude: If cruising at a low altitude you may have sufficient manifold pressure with superchargers completely off. However, under icing conditions and extremely cold air temperatures, it is important to keep superchargers engaged and operating to prevent induction system icing and with oil regulated turbos, to insure warm oil to the supercharger regulators.

1. Engage superchargers and increase desired manifold pressure 1½".
2. Reduce throttles to re-establish desired manifold pressure.

Above 20,000 feet: Superchargers won't function properly when engines are operating at less than 1800 rpm above 20,000 feet, because in thinner air there is insufficient exhaust gas to operate the turbo wheel at the necessary speed. Don't suspect turbo regulator trouble until you have checked rpm.

Cowl Flaps

Regulate cylinder-head temperatures with cowl flaps. The closed position reduces drag and increases speed.

Directional Gyro

Check and correct for precessing at least every 15 minutes, or as often as necessary.

Note: Although pilot and copilot will be checking instruments regularly, it is a good idea to call for a complete check and report by the copilot at regular intervals.

Flying the Airplane

Take pride in your ability to fly the airplane as perfectly as possible. You can't expect your copilot and your crew to develop keen interest in the technique of their jobs unless you set an outstanding example.

Heading

Hold your heading. If you are going to change heading, or dive or climb, warn your navigator in advance exactly what to expect. Know where you are, but let the navigator navigate. Require position reports every 30 minutes.

Altitude

Hold your altitude. Don't be satisfied with 200 feet higher or lower.

Airspeed

As time passes and your fuel load lightens, your airplane will tend to gain airspeed. Maintain your recommended IAS (**i.e.,** 150-155 mph for long-range cruising) by reducing rpm every 1 to 3 hours. This is always a good rule for efficient cruising.

Automatic Pilot

See section on use and operation of automatic pilot.

Flight Performance Record

It is the copilot's duty, with the assistance of the engineer, to keep a flight performance record of every mission. (See suggested form.) Preferably entries should be made every 30 minutes. Properly kept, this form will:

1. Warn you of excessive gas consumption.
2. Give a running report of the performance of engines.
3. Provide a check on how efficiently you are flying the airplane.

Engineer's Hourly Visual Check

Require the engineer to make a visual check once an hour of instruments, engines, nacelles, fuel cell areas. Above 15,000 feet this check can be postponed at the direction of the pilot for purposes of crew safety.

Oxygen

When on oxygen require a check of the crew at least every 15 minutes by interphone to ascertain that crew members are all right and have an adequate supply of oxygen.

FLIGHT PERFORMANCE RECORD

Airplane No.	Date	Pilot
Time of T.O.	To	Copilot

Time	I.A.S.	Alt.	Free Air Temp.	Fuel in Tanks								Fuel Consumed in Last Period		RPM			
				1	2	3	4	LBB	RBB	L. Aux.	R. Aux.	Gals.	Gals. Per Hr.	1	2	3	4

FLIGHT PERFORMANCE RECORD—Continued

Wt. at T.O.	Total Oil at T.O.	Mission
C.G. at T.O.	Total Fuel at T.O.	From:

Manifold Pressure				Mixture Control				Cyl. Head Temp.				Oil Pressure				Oil Temperature				Wt.	Pos. of C.G.
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		

Long-Range Cruising

For normal long-range cruising (with all engines operating, and no external loads):

1. Below 20,000 feet set rpm to maintain an IAS of 150 mph, manifold pressures of 29″ (+ or — 1″) Hg., 1400-2000 rpm as required.
2. Above 20,000 feet use 29″ (+ or — 1″) Hg. and an rpm necessary to maintain an IAS of 140 mph.
3. If long-range cruising speed cannot be maintained up to 2000 rpm, use higher rpm with correspondingly higher recommended manifold pressures.
4. With Grade 100 fuel, at or below 2100 rpm and 31″ Hg., use "AUTO-LEAN" mixture. (You may use "AUTO-LEAN" with Grade 91 fuel below 28″ Hg. and 1800 rpm.)
5. Close cowl flaps or adjust for proper cylinder-head temperature (205°C or below).
6. Hold power setting and let airspeed increase up to 155 mph as fuel is used. Re-set rpm every 3 hours to maintain desired cruising speed.

Reason why airspeed is maintained at 140 mph: power necessary to maintain 150 mph increases with altitude to a point where "AUTO-RICH" mixture becomes necessary unless airspeed is reduced, thereby using more fuel.

For long-range cruising (a) **with one engine dead,** (b) **with 2 engines dead,** (c) **with all operating, carrying extra bomb loads:**

1. Use the same manifold pressure as stated above.
2. Fly at 145 mph IAS below 20,000 feet.
3. Fly at 130 mph above 20,000 feet.

The reduced airspeed is necessary under these conditions because of increased power requirements, and for the same reason as at high altitudes: higher airspeed would require rich mixtures and cause engine inefficiencies.

Maximum Endurance

To remain aloft for the greatest possible length of time with a given amount of fuel (and where distance flown is no consideration), you will have to employ a technique considerably different from that used for long-range cruising. This technique is sometimes called **hovering.**

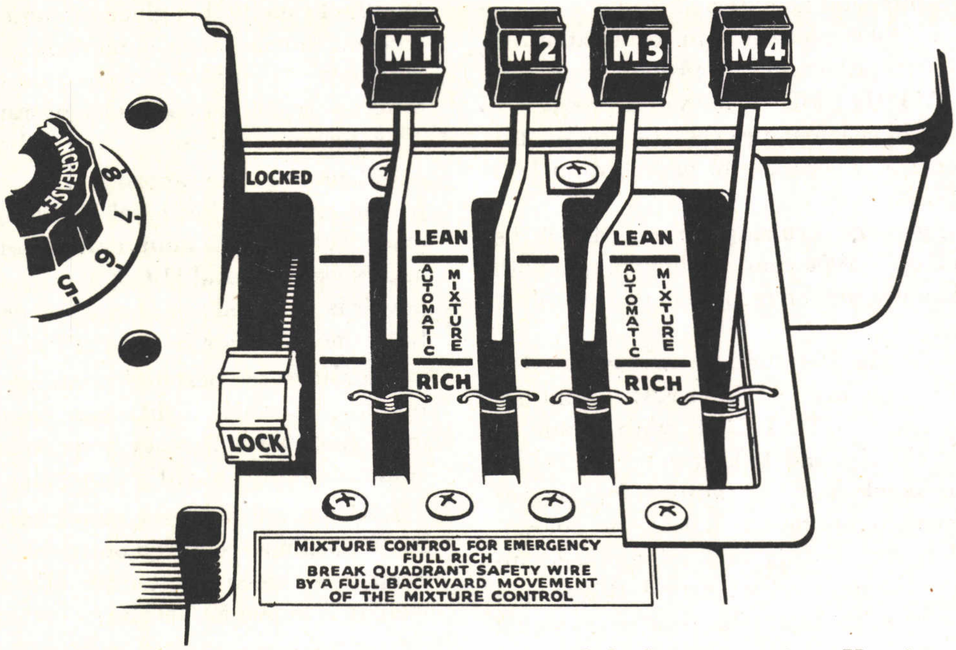
Calculating the approximate variations in power required for level flight in a medium gross weight B-17: **minimum** power is required at airspeeds around 110 mph; only slightly more power is required at 120 mph; whereas substantially more power is required at 130 mph.

Therefore, the best and safest hovering (maximum endurance flight) can be done at 120 mph, since there is reserve speed and fuel consumption is only slightly more than at 110 mph.

1. Using no flaps, set manifold pressures at 28″ Hg., rpm as required down to 1400 rpm, and keep an airspeed of 120 mph. (130 mph if gross weight is above 50,000 lbs.)
2. If lower power than 29″ Hg. and 1400 rpm is needed to maintain 120 mph, reduce manifold pressures to 26″ Hg.
3. Do not feather any engines.
4. As in cruising, the lower altitudes will yield the best performance. Reasonable altitude (several thousand feet above the ground), obviously, must be maintained.
5. Remember that the generators will not deliver full output when engines are operating at less than 1500 rpm.
6. Turbos will not function properly when engines are operating below 1800 rpm above 20,000 feet.

Reference: Flight Operation Instruction Charts, and Composite Cruising Control Chart, AN 01-20-EG-1 and T.O. 02-1-38.

USE OF MIXTURE CONTROLS



The mixture control lever on the pedestal has four operating positions:

"AUTO-RICH" position maintains the necessary fuel/air ratio for all flight conditions. At high power, the proportion of fuel to air is relatively high, to suppress detonation and aid in cooling. As power is reduced the proportion of fuel decreases. "AUTO-RICH" mixture is normally used for all ground operation, take-off, climb, landing, and certain conditions of cruising.

"AUTO-LEAN" position results in leaner fuel/air ratios than "AUTO-RICH." During the favorable conditions of stabilized level flight or a cruising descent, "AUTO-LEAN" may be used when fuel economy is of primary importance and when cooling is adequate.

In both of these two automatic settings an aneroid corrects the mixture for changes in air density caused by varying altitudes and temperatures.

"FULL-RICH" setting cuts out the automatic mixture control, providing a rich constant fuel/air ratio that becomes richer with altitude. This setting may cause rough engine operation and loss of power, in addition to greatly increased fuel consumption. Use it only when automatic control fails, or to cool the engines when a high rate of climb with rated power causes excessive head temperatures that cannot be lowered by other means. "FULL-RICH" position is normally sealed off by light weight safety wire to prevent accidental use.

"IDLE CUT-OFF" position stops all fuel flow, regardless of fuel pressure. This position is intended for stopping the engine without the hazard of backfiring.

The position markings on the quadrant are not always accurately placed, but there is a definite "feel" when you move the mixture control lever into the "AUTO-RICH" or "AUTO-LEAN" position. When you move the lever to one of these two settings make sure that it is exactly in the notch, not slightly above or below. More important, do not attempt to lean the mixture manually by moving the lever beyond the "AUTO-LEAN" position. The predetermined "AUTO-LEAN" setting gives fuel economy within 1% of the best obtainable by manual leaning under carefully controlled conditions. Therefore you gain nothing by attempting manual leaning and you may induce backfiring or detonation before you know it.

POWER SETTINGS

FOR GRADE 100 AND GRADE 91 FUEL

The 2 accompanying charts present a clear picture of the engine operating limits for Wright R-1820-97 engines using Grade 100 and Grade 91 fuel.

The charts are divided into 3 **regions of operation.** The "Desirable Region of Operation" is in the center, and is based on the allowable limits within which a given combination of manifold pressure and engine rpm will produce economical fuel consumption and avoid pre-ignition and detonation. To the left of the "Desirable Region" lies the "Prohibited Region" where excessive engines pressures cause pre-ignition and detonation. **To the right** of the "Desirable Region" lies the "**Region of Excessive Consumption.**"

Desirable Region of Operation

The meaning of this designation is obvious: If the pilot chooses to operate outside the region indicated, he can expect the consequences—detonation or excessive fuel consumption.

The black points between the lines indicate the recommended power settings. Notice that 1″ of manifold pressure more or less is considered allowable.

The power settings in the "Desirable Region of Operation" on the accompanying chart are recommended for the best all-round engine performance when operating on Grade 91 fuel. Exceeding these manifold pressures at a given rpm **will result in detonation and undue stress on the engine;** operating at a lower manifold pressure for a given rpm **will result in excessive fuel consumption.**

A dead sparkplug can cause detonation, which will develop into pre-ignition on the side of the piston where the dead sparkplug is installed.

Bear in mind the relationship of manifold pressure to engine revolutions. The settings recommended for a given power output are **minimum rpm** and **maximum pressure.** While an increase in rpm and a reduction in manifold pressure would result in a condition more favorable to long engine life, it would also result in excessive fuel consumption.

Detonation and Pre-ignition

Detonation may be described as the condition in which the fuel charge of the cylinder fires spontaneously and too rapidly instead of progressively burning over a longer period of time.

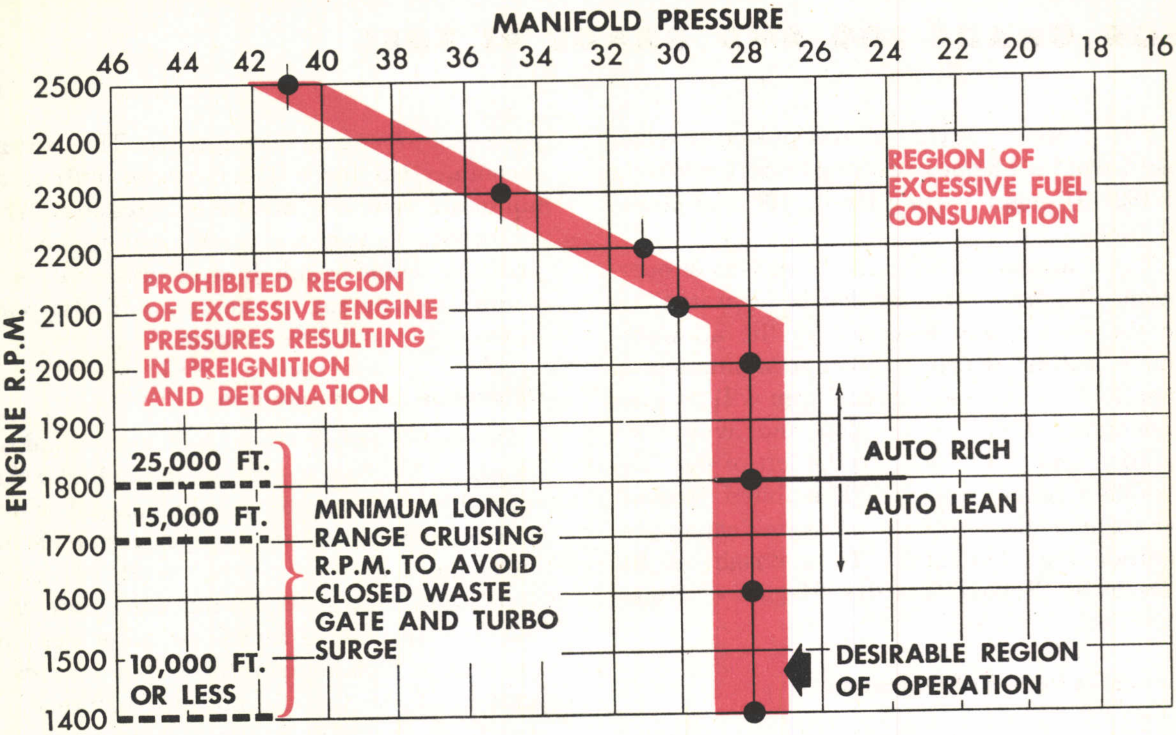
Pre-ignition is one of the results of detonation. Local hot spots within the combustion chamber (excessive carbon or other deposits) reach such high temperatures that they cause ignition of the fuel-air mixture before it can be ignited normally by the ignition spark. Pre-ignition is even more severe than detonation itself in its effect on the engine. The engine will not continue to operate for more than a short time when pre-ignition is present.

Results of detonation or pre-ignition are: (1) reduction in power output, (2) possible engine failure, (3) actual damage to the engine parts.

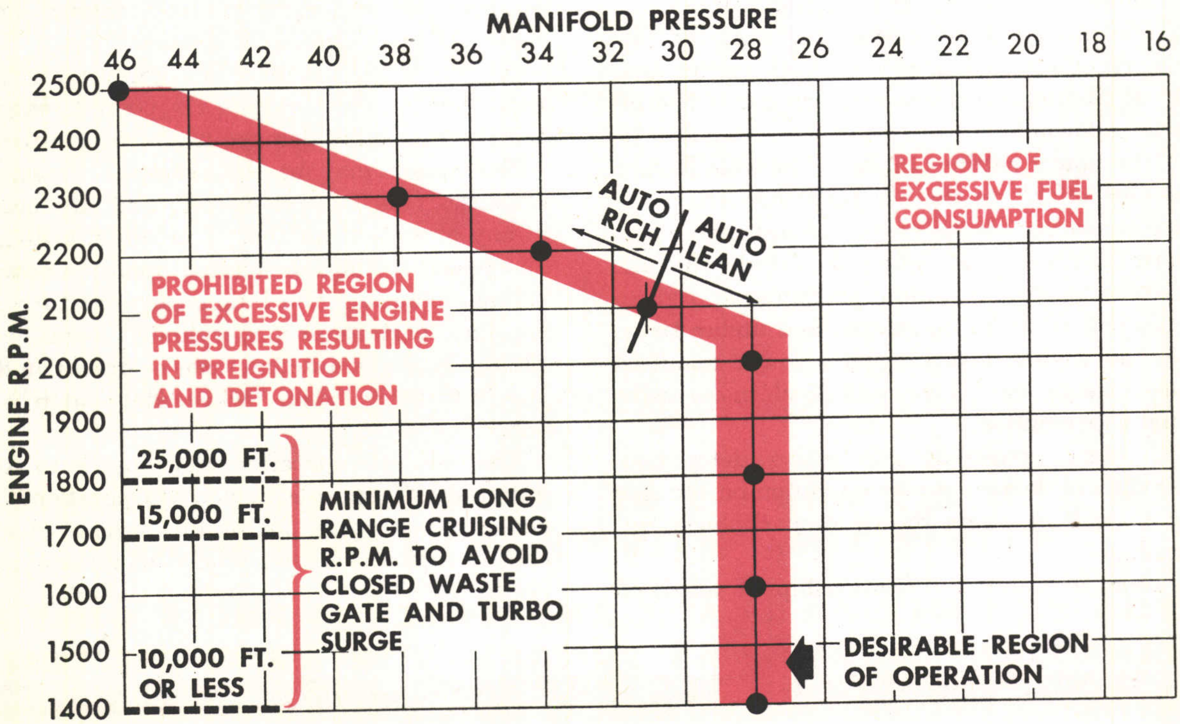
Detonation may be the result of a variety of causes (see T.O. No. 02-1-7) and may occur at any of a great number of manifold pressure and power settings depending upon the octane rating of the fuel, the original temperatures of gasoline, carburetor air, cylinder heads, etc. Therefore, no definite lines can be drawn on the charts to show exactly where detonation will occur.

The only safe operation procedure is to stay within the "Desirable Region of Operation" or, conversely, to stay out of the regions of excessive engine pressures where detonation may occur.

POWER SETTINGS FOR GRADE 91 FUEL



POWER SETTINGS FOR GRADE 100 FUEL



POWER SETTINGS

SPECIFICATION AN-F-26 GRADE 91 FUEL

CONDITION	RPM	MP	MIX	MAX. CYL HEAD TEMP.	ESTIMATED GPH
TAKEOFF	2500	41	AUTO-RICH	260	480
CLIMB OR MAXIMUM CONTINUOUS	2300	35	AUTO-RICH	232	370
FAST CRUISE	2200	31	AUTO-RICH	218	300
MED CRUISE	2100	30	AUTO-RICH	218	265
LONG RANGE	2000	28	AUTO-RICH	218	215
POWER AS REQUIRED	1800	28	AUTO-LEAN	218	160
FLY TO TARGET AT 155 IAS	1600	28	AUTO-LEAN	218	150
RETURN FROM TARGET AT 140 IAS	1400	28	AUTO-LEAN	218	120
HOVER 120 IAS	AS REQ. 1400 MIN	28 MAX.	AUTO-LEAN	218	100 MIN

GRADE 91 FUEL

POWER SETTINGS

GRADE 100 FUEL

CONDITION	RPM	MP	MIX	MAX. CYL TEMP. C	APPROX GPH 4 ENGINES
TAKE OFF	2500	46	AUTO-RICH	260	555
CLIMB OR MAXIMUM CONTINUOUS	2300	38	AUTO-RICH	232	400
FAST CRUISE	2200	34	AUTO-RICH	218	335
MED CRUISE	2100	31	AUTO-LEAN	218	255
LONG RANGE	2000	28	AUTO-LEAN	218	190
FLY TO TARGET AT 155 IAS	1800	28	AUTO-LEAN	218	160
	1600	28	AUTO-LEAN	218	150
RETURN FROM TARGET AT 140 IAS	1400	28	AUTO-LEAN	218	120
HOVER 120 IAS	AS REQ. 1400 MIN	28 MAX.	LEAN	218	100 MIN

GRADE 100 FUEL

IF YOU MIX GRADES OF FUEL YOU MUST OPERATE WITHIN THE LIMITS OF THE LOWER GRADE

YOU CAN MIX AROMATIC AND CRACKED FUELS ONLY IF TANKS ARE MARKED AS SUITABLE FOR AROMATIC FUELS

FLIGHT CHARACTERISTICS

The B-17 possesses many outstanding flight characteristics, chief among which are: (1) directional stability; (2) strong aileron effect in turns; (3) ability to go around without change in elevator trim; (4) exceptionally satisfactory stalling characteristics; and (5) extremely effective elevator control in takeoff and landing.

Trim Tabs

The airplane will go around without changes in elevator trim tab settings. However, trim must be changed with adjustment of cowl flaps and power settings, for these reasons:

1. Increased power on the inboard engines causes the airplane to become slightly tail-heavy. (Power change on the outboard engines has no appreciable effect on trim.)

2. Closing the cowl flaps on the inboard engines also causes tail-heaviness. (The effect of cowl flaps on the outboards is negligible.)

With the airplane properly trimmed for a power-off, flaps-down landing, you can take off and go around again by applying power and putting the flap switch "UP" with no change in trim. The flaps will retract at a satisfactorily slow rate. The nose must be raised slightly to offset the loss in lift when flaps come up.

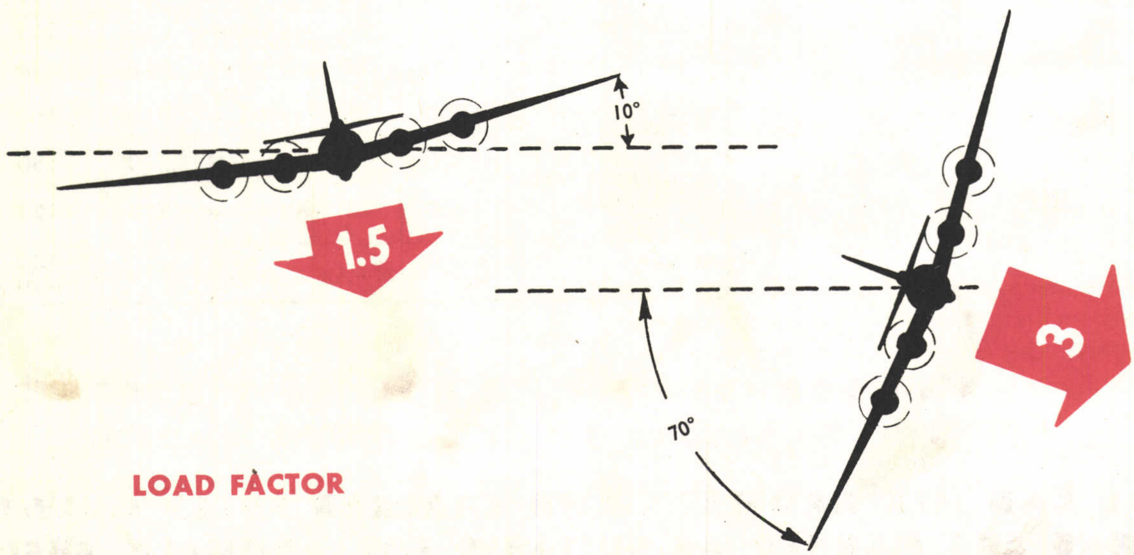
Turns

Because of the inherent directional stability of the B-17, dropping one wing will produce a noticeable turning effect. Very little rudder and aileron will enable you to roll in and out of turns easily. Carefully avoid uncoordinated use of aileron.

In shallow turns the load factors are negligible. But in steeper turns proportionately more back pressure is required, thereby increasing the load factor.

In banks from 10° to 70° the load factor increases from 1.5 to 3.0. Obviously, steep turns of a heavily loaded airplane may place sufficient stress on the wings to cause structural failure.

If the airplane tends to slip out of turns, recover smoothly without attempting to hold bank. Decrease the bank. Use proper coordination of rudder and aileron.



LOAD FACTOR

Flaps

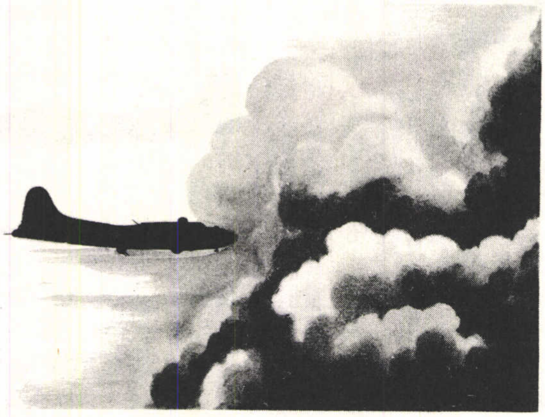
Use of flaps increases the lift of the wing by changing its effective camber, but also creates a large increase in drag. Therefore, the B-17 wing is most efficient with flaps up.

When fully extended, as for landing, the flaps reduce the stalling speed and increase the rate of descent, enabling you to steepen your gliding angle on final approach. Do not use flaps to decrease the gliding speed.

Don't use flaps to try to stretch the glide or to hold altitude; use of flaps does not increase efficiency of the wing.

Rough Air Operation

In rough air, use both rudder and ailerons without worrying about excessive loads. Both aileron and rudder forces vary with changes in airspeed in such manner that it is almost im-



possible to damage the system without deliberately trying to do so. Necessary control pressures are small enough, and the responses large enough, to maintain ample control of the airplane.

However, in the case of the elevators, exercise great care, both in rough air and in recovery from dives, to assure smooth operation. In thunder storms, squalls, and in or near turbulent cumulus clouds, it is possible to develop excessive load factors by means of the elevators unless they are used properly. This does not mean that there is any greater tendency to exceed allowable load factors in the B-17 than in other heavy bombardment or transport airplanes. It means that **the larger the airplane, the greater the time and distance required to complete any maneuver.** In operation, you **must** allow more distance and time in proportion to the size of the airplane.

Generally, in rough air, hold constant airspeed by means of the elevator, but do it smoothly. Remember that recovery to the desired airspeed may take time.

Avoid hurried recovery from dives, climbs or changes in airspeed. Never dive the airplane through a cloud layer or through rough air at maximum diving speed. Don't attempt high-speed flight in rough air.

Stalls

The stall characteristics of the B-17 are highly satisfactory. The tendency to roll—commonly caused by lack of symmetry in the stalling of either wing—is minimized by the large vertical tail. Under all conditions a stall warning at several mph above stalling speed is indicated by buffeting of the elevators.

If airspeed is reduced rapidly near the stall, the speed at which the stall will occur will be lower than when the stall is approached gradually. The stall will also be more violent because the wing's angle of attack will be considerably above the stalling attitude.

The stalling speed of the B-17, like that of any other airplane, depends upon: (a) the gross weight, (b) the load factor (number of Gs), (c) the wing flap setting, (d) the power, (e) de-icer operation and ice formation.

The effect of gross weight upon stalling speed is obvious: the heavier the load, the higher the stalling speed.

The effect of the load factor is simply to increase the effective gross weight in proportion to the load factor.

The greater the flap angle the lower the stalling speed. The greater the power, the lower

the stalling speed. Full flaps reduce the stalling speed about 15 mph for gross weights of 40,000 to 45,000 lb., and a load factor of 1.0; but full military power for the same loading conditions may reduce the stalling speed another 15 mph.

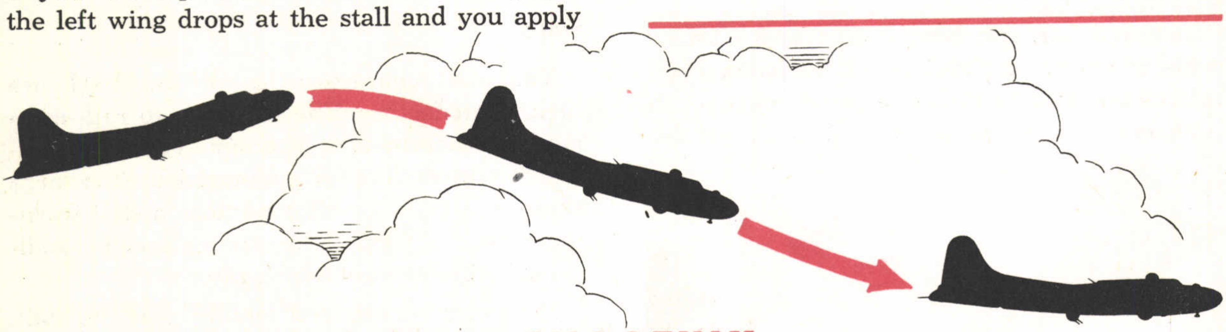
The power-off stalling speeds of the B-17 F & G are shown below. The true stalling speeds of the two airplanes are actually the same, but the difference in the pitot static systems causes the airspeed indicator of the two series airplanes to read differently at these speeds. The B-17F indicator will read too high while the B-17G has only a small error at low speeds. Thus the B-17G will stall at a lower **indicated** airspeed.

Any yawing, accidental or otherwise, will increase the stalling speed and any tendency to roll at the stall. This is obvious, since the normal procedure in deliberately making a spin is to yaw the airplane as it stalls. For example, if the left wing drops at the stall and you apply right aileron to raise the left wing, the ailerons will have a tendency to overbalance and **reverse** effectiveness, because of the drag induced by the aileron. The result will be increased dropping of the left wing. The aileron procedure in recovering from a stall, therefore, is to **hold ailerons neutral and refrain from their use until coming out of the dive in the final phase of recovery. Use rudder in stall recovery.**

POWER OFF STALLING SPEEDS—WHEELS *UP*

Pilots Indicated Airspeed

Gross Weight	Flaps Up	⅓ Flaps	Full Flaps
	F G	F G	F G
65,000	128—114	121—109	110—101
60,000	123—110	116—105	106— 97
55,000	117—105	111—101	101— 92
50,000	112—100	106— 96	96— 88
45,000	106— 95	100— 91	91— 84



RECOVER FROM STALL SMOOTHLY

Stall Recovery

For the B-17 the procedure for recovering from a stall is normal.

1. Regain airspeed for normal flight by smooth operation of the elevators. This may require a dive up to 30°.

2. While regaining airspeed, use rudder to maintain laterally level flight. After airspeed is regained, use ailerons also for lateral control—**but not until airspeed is regained.**

The important thing is to **recover from the dive smoothly.** Penalty for failure to make a smooth recovery may be a secondary stall or structural damage to the airplane, both because of excessive load factors. Rough or abrupt use of elevators to regain normal flying speed may cause the dive to become excessively steep.

The additional airspeed necessary to regain normal flight need not be more than 20 mph. This means that excessive diving to regain airspeed is absolutely unnecessary.

Remember these additional facts about stalls:

1. Wheels down increase the stalling speed about 5 mph.

2. Wheels and flaps down decrease the stalling speed about 10 mph.

3. De-icer boots operating increase the stalling speed 10-15 mph. In recovering from stalls with de-icer boots operating, regain slightly more than the usual 20 mph needed for recovery. Such stalls are apt to be more abrupt, with a greater tendency to roll.

Spins

Accidental spinning of the B-17 is extremely unlikely. The directional stability and damping are great, and it is probable that even a deliberate spin would be difficult. However, remember that **the airplane was not designed for spinning, and deliberate spins are forbidden.**

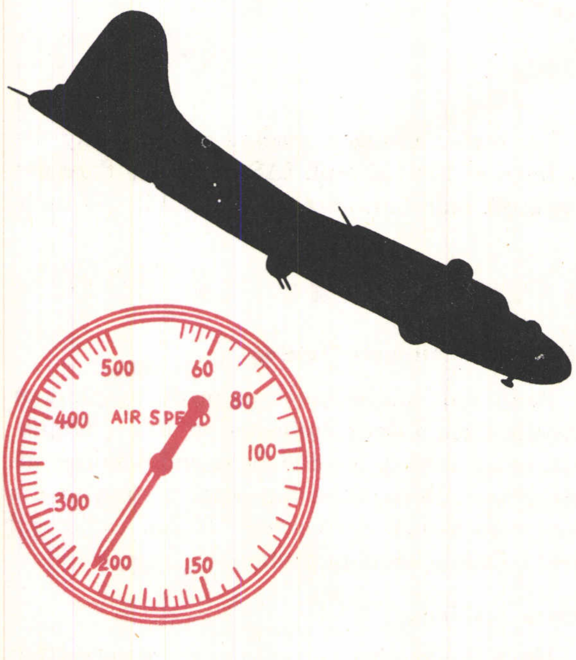
Dives

The maximum permissible diving speed in the B-17 (wheels and flaps up) with modified elevators and strengthened stabilizer is 305 mph IAS. If only the elevator has been modified the limit is 270 mph IAS. With neither the reinforced stabilizer nor the modified elevators, the maximum diving speed is limited to 220 mph IAS.

The factors limiting the diving speed of the B-17 are the weight, elevator and stabilizer strength, the engine ring cowl strength, the wing leading-edge de-icer boot strength, the antenna strength, the cockpit windshield and canopy strength, and the critical flutter speed. The engine ring cowl has been designed to withstand 420 mph. The windshield and cockpit canopy have ample margin at 305 mph. The wing leading-edge de-icer boots begin to raise slightly from the wing at 305 mph, and any additional speed would be likely to lift the upper part of the boot above the wing surface, possibly causing structural failure. The mass balance of the control surface is so essentially complete both statically and dynamically that, basically, the critical flutter speed depends entirely on the wing-bending torsion critical speed, which is approximately 375 mph.

Therefore, it is obvious that simply diving the airplane (with modified elevators) to 270 mph involves no danger whatsoever. The only danger that must be considered is in recovery. Recovery must be smooth and gradual. Normally, a load factor of 2 will not be exceeded. At the gross weight of 50,000 lb., the initial-yield point factor is slightly less than 3, making the ultimate load factor slightly over 4. Obviously, at that gross weight the load factor 3 should never be reached; the load factor 2 normally will not be exceeded.

There is no reason to dive the airplane deliberately at over 220 mph except in an emergency.



MAXIMUM DIVING SPEED WITHOUT ELEVATOR MODIFICATIONS IS 220 MPH.

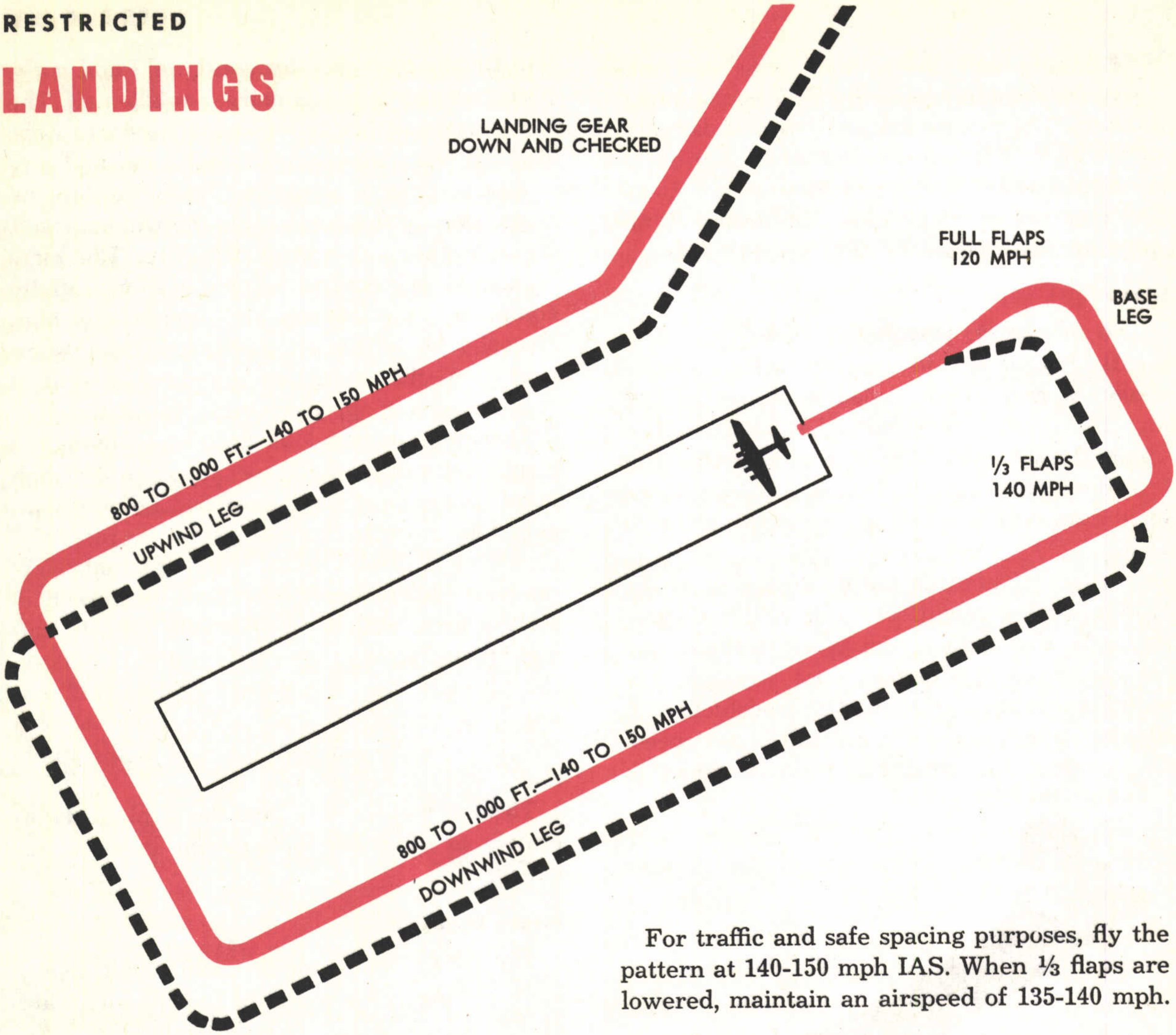
Heavy Loads

The B-17 is stable longitudinally with heavy loads as long as the center of gravity is forward of 32% of the Mean Aerodynamic Chord (87 inches aft of the leading edge of the center section).

For all normal loading the CG must be kept forward of 32% of the MAC. If an excessive load is placed in the rear, the airplane will have neutral or negative stability. It is possible to trim the airplane with an unstable load, but it will be difficult to fly, especially on instruments. It is also much easier to stall inadvertently when flying an unstable airplane on instruments.

Loading for the forward CG positions is preferred because, in addition to being easier to fly, it gives a smooth increase in elevator forces required to pull out of dives, and eliminates the necessity of using excessive elevator trim to hold the tail up.

LANDINGS



The before-landing check (see Pilot's Checklist) is used when returning from a mission that takes the airplane away from the home field, **i.e.,** for other than traffic pattern work. Complete this check before entering the traffic pattern, so that thereafter you will be able to devote your undivided attention to traffic and landing.

Traffic Pattern

The traffic pattern and the rules for entering and flying it are prescribed by local field regulations. At the majority of B-17 stations within the continental U.S., the pattern is rectangular in shape. The pattern altitude may vary, but generally it is between 800 and 1000 feet above the ground.

For traffic and safe spacing purposes, fly the pattern at 140-150 mph IAS. When 1/3 flaps are lowered, maintain an airspeed of 135-140 mph.

BEFORE-LANDING CHECK

Radio Call, Altimeter Setting

Radio call to the tower is made by pilot or copilot (see **Pilot's Information File**). Obtain altimeter setting for the field and landing instructions. Repeat the altimeter setting to the tower to insure correctness. (Final radio call will be made while in traffic.)

Crew Positions

Have the engineer check the crew to see that all members are in proper positions for landing.

The radio operator will check the trailing antenna and see that it is retracted.

Gunners will check their guns and make sure they are in proper position for landing.

Automatic Pilot

See that the automatic pilot is "OFF." All switches must be turned "OFF" to eliminate any possibility of accidental engagement.

Booster Pumps

Check the booster pumps "ON."

Mixture Controls

Check mixture controls in "AUTO-RICH."

Intercoolers

Be sure the intercoolers are in the "OFF" or ("COLD") position for landing.

When freezing precipitation is present during the approach glide to the runway, and there is danger of carburetor icing, turn the intercoolers "ON," but be sure to notify all persons on the flight deck. This will serve as a reminder to all that, if full power is needed, the intercoolers must be turned "OFF."

Carburetor Filters

Place the filters in the "ON" (open) position to keep foreign matter out of the induction system.

De-icers and Cabin Heat

Check the wing de-icer boots: controls should be in the "OFF" position except when testing or actually in use.

Make a visual check to be sure the de-icer boots are deflated before the final approach. Remember that action of the wing de-icer boots disturbs the flow of air over the lifting surfaces and increases the stalling speed.

Check propeller anti-icers "OFF."

Turn glycol type cabin heaters "OFF." If you have exhaust heat exchange type heaters the controls may be in any desired position.

Landing Gear

If there is a "Push to Test" light on the landing gear warning light instruct the copilot to test it to see if the warning light is working. Then have him put the landing gear switch in the "DOWN" position when airspeed is under 180 mph. Make a visual check from the left-hand window, and report aloud: "Down left." The copilot will make a similar check on his side and will report: "Down right." Also check wheels for cracked rims and evidence of hydraulic lines leaking. The wheels usually revolve slowly after extension. This is a check that brakes are "OFF." From the rear of the airplane the engineer will check the tailwheel (with the hand crank if there is any evidence that the gear is not down completely) and report: "Tailwheel down." At the same time, the engineer will visually check the condition of the tailwheel assembly (no worn threads or gear, etc.) and see that the trailing antenna is retracted and ball turret is stowed properly.

Check Landing Gear Warning Lights

Copilot returns switch to neutral position and checks warning light: green light on.

Hydraulic Pressure

Check hydraulic pressure gages (normal pressure—800 lb.) and fluid level. Check operation of hydraulic pump. Check the position of the spring loaded toggle switch on the pilot's control panel. It should be in "AUTO" unless the hydraulic pump will not cut in automatically. This occurs on most series when the system pressure falls below about 300 psi. In this event hold the switch in "MANUAL" until the pressure rises to 300 psi., then release the switch. It will return to "AUTO," and the pressure should build up to 800 psi. To test whether the hydraulic pump is operating properly, depress the brakes several times to lower the hydraulic pressure to about 600 lbs., when the pump should cut in. (See "Brake Operation With Hydraulic Pump Failure.")

Be sure the cowl flap controls are in the "LOCKED" or neutral position to prevent any loss of oil supply through leaks in the actuating mechanism.

If in doubt about hydraulic pressure, instruct the copilot to stand by on the hand pump, awaiting your signal.

Increase RPM

In the traffic pattern, signal the copilot to increase rpm to 2100 to 2300, depending on weight and landing conditions.

Turbos

Decrease manifold pressure to about 23″, then signal the copilot to place the turbo controls full "ON," readjust manifold pressure to desired value. Be extremely careful that allowable manifold pressures are not exceeded with the turbos in the full "ON" position. This is important in case an emergency takeoff or go-around is necessary after an attempted landing. Normally, full takeoff manifold pressure will not be needed in such an emergency, since the airplane still will be at or near flying speed and no original inertia has to be overcome.

Flaps

Lower ⅓ flaps after airspeed has been reduced below 147 mph.

FINAL APPROACH

Flaps

For normal landings, place the wing flaps in the full down position on the final approach. However, in heavy winds or heavy crosswinds partial flaps produce better results.

In the event of an emergency takeoff or go-around after an attempted landing, do not retract flaps until full power has been applied.

High RPM

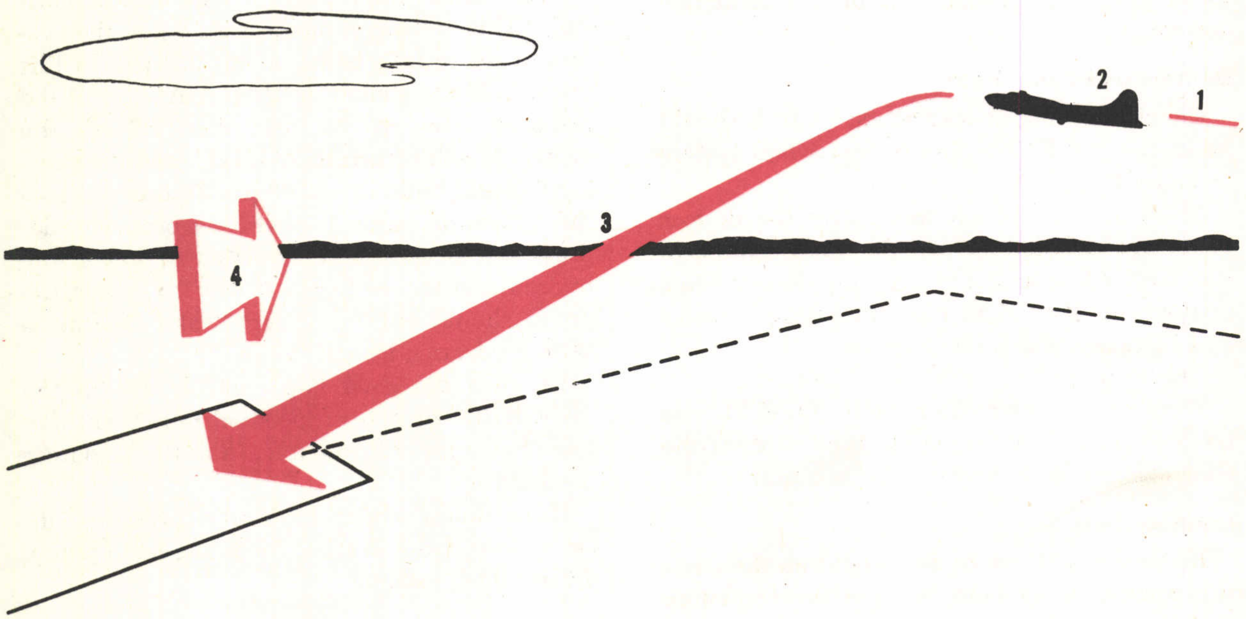
While fully retarding throttle, signal the copilot to move propeller controls to full "HIGH RPM."

Power-Off Approach

The power-off approach can be executed successfully in normal empty-weight B-17's, and is taught in transition schools.

The important factors in making a successful power-off approach are:

1. Distance from the field—base leg should be not more than three miles out.
2. Proper traffic altitude.
3. Airspeed and angle of glide.
4. Wind and atmospheric conditions (temperature, density, etc.).



FOUR VARIABLES AFFECTING THE ACCURACY OF LANDING

These are the 4 variables. The first 3 are under your control; the fourth—the wind and atmospheric conditions—can be taken care of by proper application of the first 3 factors.

Usually, a good approach means a good landing. The best approach can be made by setting the base leg approximately 2 miles from the field, never more than 3 miles.

Maintain altitude throughout the turn on the approach.

The third and most important consideration in the successful approach and landing is to maintain a constant glide. Roll out of the turn on the approach, lower flaps, maintain altitude and reduce power at the proper point. Smoothly blend power reduction to the change to gliding attitude.

A good or bad landing of a 4-engine airplane usually is determined by the time it has descended to 300 feet. By that time the pilot should have established constant glide, constant airspeed, constant rate of descent, and made an accurate judgment of distance. If he has accomplished these things, the landing is in the bag.

Proper altitude for breaking a power-off glide is approximately 150 feet with a medium load. The flatter the glide, the lower the glide may be broken.

Level off for landing smoothly and gradually. In the B-17 an abrupt change of attitude from the vertical to the horizontal plane will increase the wing loading, thereby increasing the stalling speed. There is no danger of this if you level off smoothly and gradually.

Power Approach

The same 4 variables—setting the base leg, proper traffic altitude, holding constant airspeed and angle of glide, and reckoning with the wind and air conditions, govern the success or failure of the power approach.

The power approach does **not** mean flying the airplane in at excessive speed and skimming over half the runway's length. Nor does it mean bringing the airplane in at such a low speed that it is virtually hanging on the prop to stall in as soon as throttles are cut.

The power approach is a **controlled glide** in which power is used to obtain accuracy in landing on a selected spot, and greater control of the airplane.

Put down flaps and reduce power on the approach. Continue to reduce power **gradually** until the desired airspeed and rate of descent have been established. (Approximately 15" Hg. on the B-17E, and approximately 20" Hg. on the B-17F and B-17G.) Hold a desired manifold pressure until you are ready to close throttles when nearing the runway. This eliminates any need for jockeying throttles back and forth, and makes for a smooth, precise landing.

Normally, the gliding speed should be maintained at 120 mph; but this will vary with the gross weight and CG location, rigging, angle of descent, wind conditions, and pilot technique. Correct glide usually results from bringing these factors into harmonious relationship. Proper gliding speed is approximately 20% above stalling speed for a B-17 with a medium load.

Strong Winds

When landing in strong winds, the use of full flaps often is inadvisable. Use your discretion as to the amount of flaps to use. However, never use less than ½ flaps. Flaps may be dumped immediately after touchdown to help keep the airplane on the ground.

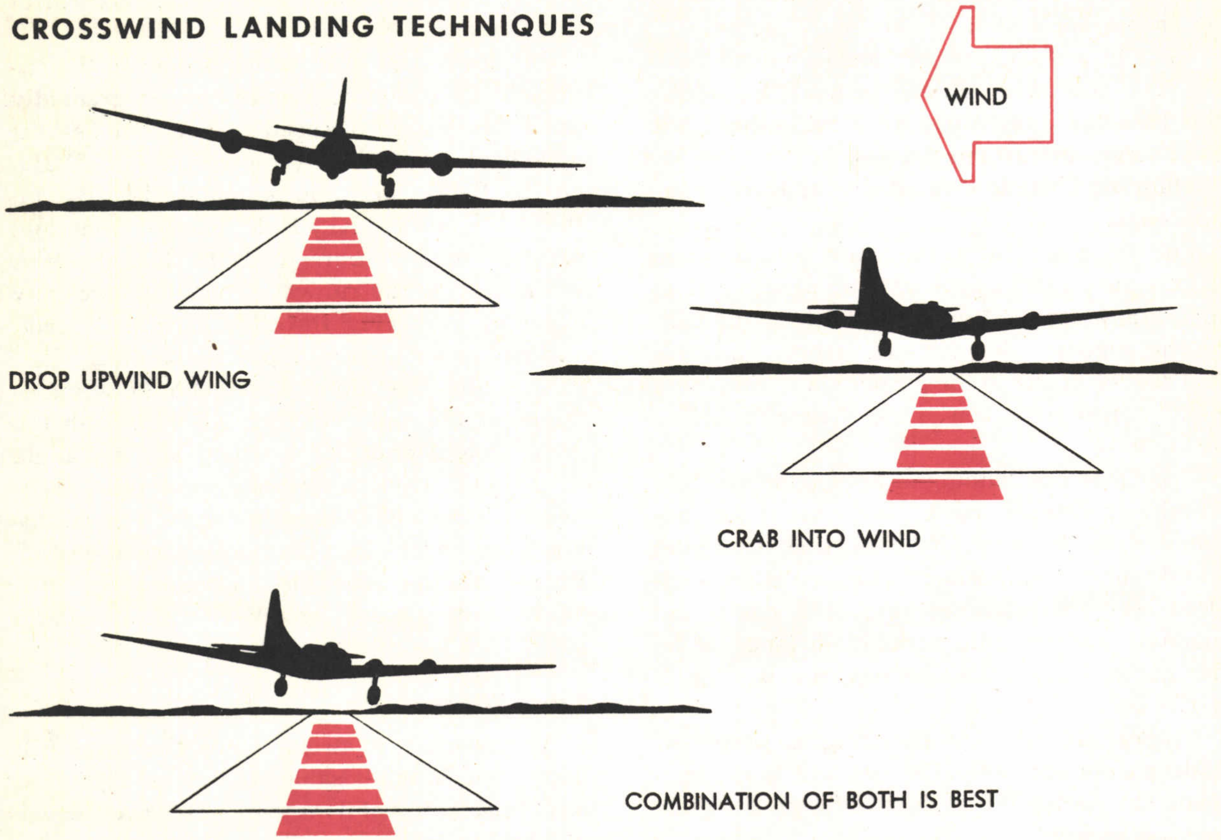
Crosswinds

When turning on the approach in a crosswind, be careful to prevent the wind from forcing you off your approach to a degree where it is impossible to align with the runway.

There are 3 possible ways of making a crosswind approach and landing: (1) holding the airplane straight toward the runway, dropping one wing into the wind with just enough top rudder to counteract drift; (2) heading the airplane into the wind (crabbing) just enough to keep a straight ground path; and (3) a combination of the first two methods.

The combination of methods is preferred, because it eliminates the possibility of dropping the wing too low, or of crabbing too much. It also prevents crossing controls and decreases

CROSSWIND LANDING TECHNIQUES



the amount of correction needed to straighten out and level off during the round-out.

If the airplane drifts after leveling off, nose just a little downwind. This will eliminate some of the sideload that may be placed on the wheels. However, the necessity for nosing downwind can be eliminated by gliding in with slightly less speed.

Make a 3-point landing, gliding at 120 mph with full flaps, or at 125 mph with ½ flaps.

Watch Brakes on Ground

On all landings, take particular care to avoid holding brakes while using rudder on the approach. Landing with brakes, or applying brakes before the full weight of the airplane settles, will cause blown tires and possible damage to the landing gear.

Caution

NEVER LAND WITH BRAKES ON.
NEVER APPLY BRAKES BEFORE FULL WEIGHT OF PLANE SETTLES.

GO-AROUND

If the airplane is not on the ground within the first 1/3 of the runway, **go around again and make another approach and landing.**

1. Walk up throttles slowly. Copilot will check rpm before power is increased. He will then retract the gear.

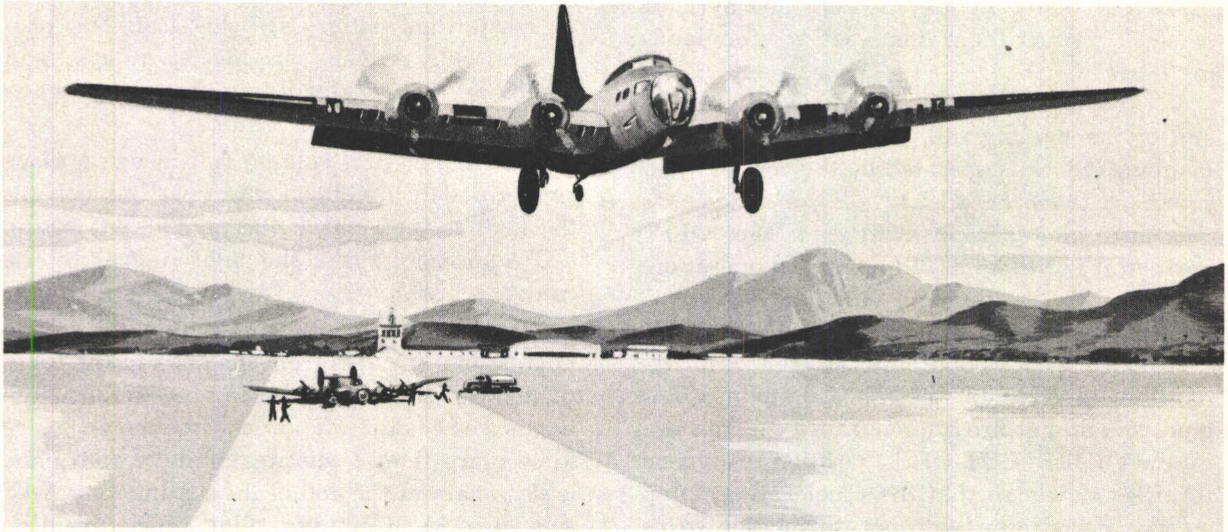
2. Retract flaps to 1/3 position immediately after applying power. While they are being retracted raise nose slightly to overcome the loss of lift which occurs as flaps come up.

3. Copilot will call airspeed while flaps are retracting. Upon attaining an airspeed of about 140 mph, fully retract flaps, reduce turbo regulators and throttles to desired setting. Signal copilot to reduce rpm. Copilot will then make an even adjustment on turbo regulators and synchronize the propellers.

Never reduce rpm before reducing manifold pressure. Remember: (1) for **reducing power,** reduce manifold pressure first, then reduce rpm; (2) for **increasing power,** increase rpm first, then increase manifold pressure.

If landing gear has been retracted, make a visual check before placing the landing gear switch in neutral. (Pilot will check and call aloud: "Up left"; and copilot: "Up right." Engineer will check tailwheel and report.)

Turn booster pumps "OFF" when leaving traffic above 1000 feet.



LANDING ROLL

After landing, use the entire runway for the landing roll, unless some emergency necessitates turning off at an intersection. Judgment of speed, and feel of the brakes, will tell you when and how to use them. After rolling half the runway, feel out the brakes by applying light pressure. If the braking effect is negligible, it means you will have to apply brakes sooner than normally in order to stop at a desired spot. If the brakes produce the desired slowing effect, you can leave them off until they are needed.

Finally, when brakes are used to slow down the airplane in order to turn off onto the taxi strip, apply them slowly and steadily, until you have attained a slow taxiing speed. Then turn off the runway. Use judgment in your application of brakes so that you will not have to apply additional power in order to turn onto the taxi strip.

AFTER-LANDING CHECK

While rolling down the runway, complete the after-landing section of the checklist.

1. Copilot checks gage for proper hydraulic pressure (600 to 800 lb.)
2. Copilot opens and locks cowl flaps to cool engine and help slow down airplane.
3. Copilot turns turbos "OFF."
4. If no further takeoff is to be made, copilot turns booster pumps "OFF."
5. Copilot raises wing flaps upon signal from the pilot. Wing flaps are an aid in decreasing speed in the landing roll, and normally will be raised at the end of the landing roll. **Make certain the landing gear switch is not confused with the wing flap switch.** When there is any possibility that flaps may be damaged by mud or slush, retract them immediately after landing.
6. Do not unlock the tailwheel before the end of the landing roll, except in emergency. (Tailwheel lock is operated by the copilot upon command from the pilot.)
7. Turn all generator switches to the "OFF" position if not to be used for ground operation.

End of Mission

After 30 seconds operation at 1200 rpm, signal the copilot to cut the inboard engines. Engines should not fire after mixture controls are in the "IDLE CUT-OFF" position. Advance throttles slowly so that the accelerating pump on the carburetor will not throw an extra charge into the cylinders and cause them to fire.

Turn off the runway and taxi toward the parking area. Be sure a crew man is out in front to guide you into the parking space.

Park the airplane with the tailwheel locked.

Be sure that chocks have been placed under the wheels before releasing the foot brakes.

Never set parking brakes upon return to the line. The hot brakes may cause the expander tubes to burst.

When the airplane is on the ramp, cut the outboard engines, after making sure that they are not fouled.

Contact tower by radio and report the airplane on the ramp.

Turn all electrical switches "OFF" before turning off master switch and battery switches. AC power switches must not be turned off until the engines have stopped and engine instruments have settled in neutral position. **Turn off master and battery switches last.** This procedure will prevent arc-ing of relays, and eliminate heavy load on batteries when switches are turned on again.

Move the control column full forward, place rudder pedals in neutral, and raise the lock (in the floor to the right of the pilot's seat) to the "UP" position. Place the aileron lock in the control wheel.

Complete Form I. Time is computed to the nearest five minutes from the start of the takeoff run to the end of the taxiing or until the engines are shut off, unless the engines are idled more than 5 minutes while the airplane is stationary at the end of the taxiing (see AAF Reg. 15-5A). Compute pilot time carefully. Make notations on Form 1A of hard landings, fires on the ground or in the air, runaway props or turbos, and anything else found wrong with the airplane. Discuss the more serious items with the crew chief.

Don't let crew leave airplane until you know engines are stopped and switches are cut.

NIGHT FLYING

Don't fall for the belief, common among less experienced flyers, that "night flying is no different from day flying." Night flying is different from day flying. Your vision at night is different because you are using a different part of your eye (see **Physiology in Flight** and AAF Memorandum 25-5). Unless lights are properly grouped (as on runways) or easily identifiable (horizons, large cities, towns, etc.), your visual references are diminished considerably. Finally, when visibility is reduced and you have no clearly defined horizon, **night flying is instrument flying.**

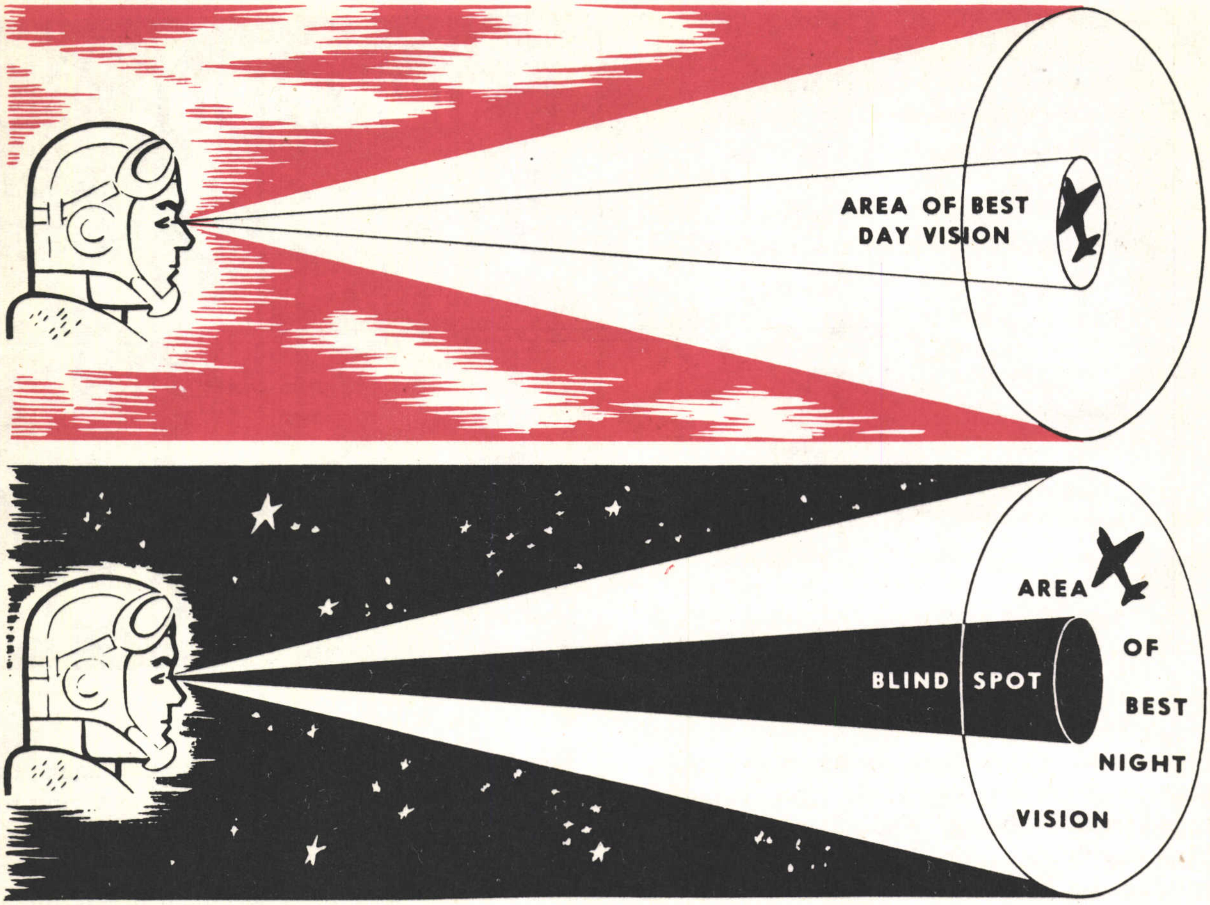
Illusions in Night Flying

Night flying can be much more confusing than simple instrument flight through clouds. Probably many of the accidents and fatalities that occur in night flying result from the fact that pilots rely too much on their vision and other senses rather than on instruments. (See T.O. No. 30-100A-1.)

The inexperienced pilot is continually looking for some light on the ground by which he can orient himself. Unless he is flying near a large city where there are enough lights to make a good pattern, this practice of trying to orient himself in relation to the terrain is extremely hazardous. Many experienced pilots can tell how they have mistaken a star for a light beneath them, or how they thought lights were moving past, when actually their plane was turning about the lights.

The reason for the particular confusion in night flying is that a pilot's eyes may deceive him. He does not have any definite horizon to use as a plane of orientation; he has only isolated points of light. His sensation may tell him that these light-points are in a completely different relationship. As a result, when the airplane does not react as he expects it to, he becomes completely confused. In addition, the inexperienced pilot usually forgets his instruments and is so busy looking around that he glances at the instrument panel only after he has become confused and is already in a bad situation.

The only solution for this is to watch the **instrument panel** with only occasional glances out at the visual reference points. In night fly-



ing, use instruments as your major reference, and scattered lights only as a secondary reference.

Tips on Night Vision

Before flight don't subject your eyes to any bright lights: brightly lighted rooms, wing light beams, bright cockpit lights, etc.

Turn out all unnecessary cockpit lights; dim instrument panel lights.

Read instruments, maps, and charts rapidly; then look away. Use red light within the airplane whenever possible.

Lack of oxygen seriously impairs vision. At 12,000 feet without oxygen, for instance, night vision is only 50% efficient. Use oxygen from the ground up on all night flights to altitude.

Night Precautions

Be sure that goggles, side windows, and wind shields are kept scrupulously clean. Scattered light on unclean surfaces reduces the contrast between faint lights and their background.

Be sure that all fluorescent lights, winglights, navigation lights, passing light, cockpit light, and instrument lights are in operating order. Be sure that pilot, copilot, and engineer have individual flashlights.

Be particularly careful in making your visual outside inspection.

Check radio operation and set proper frequencies. Your radio is especially important at night.

Know your field layout, the proper relationship of taxi strips to runways, etc. It's easy to become confused at night.

Takeoff

Obtain clearance from the tower before taxiing to the runway. Line up in the center of the runway and use runway lights for reference.

If visibility is poor and no horizon is visible, prepare to take off on instruments.

Maintain proper airspeed, but be sure you're climbing. It is imperative to hold a constant heading until you reach sufficient altitude for the turn.

Post observers at the side windows and top turret to give warning if you are turning into the path of other aircraft.

Remember that, for safety, 150 mph is the recommended climbing speed at night.

Don't start turns until you are at least 400 feet above the terrain. Don't reduce power until 200 feet altitude has been reached.

Night Landings

1. Fly compass headings on the various legs of the traffic pattern.

2. To line up properly with the runway and avoid overshooting or undershooting, begin a medium turn on the final approach **when the runway lights seem to separate.** On the downwind and base legs, the runway lights seem to be in a single row. As the airplane comes nearer to the runway on the base leg, the lights begin to separate into 2 rows. **This is the time to start the turn onto the approach.**

3. Avoid a low approach at night. Maintain constant glide, constant airspeed, and constant rate of descent by making slight changes in power and attitude.

4. Don't turn on wing lights while too high. They will become effective at 500 feet.

5. Don't try to sight down the wing light beam. Use the whole lighted area ahead and below for reference. Don't rely on winglights alone; use runway lights as a secondary reference. Winglights alone may induce you to level off for landing too late. Runway lights alone may cause you to level off too high, especially if there is haze or dust over the field.

6. If you are uncertain of your final approach, carry a little more power; this will prevent stalling out high. Carry power until you are sure of making contact with the ground. Avoid cutting power too high or too soon.

7. Check generators and batteries for proper operation. They carry a heavier load at night.

8. Check auxiliary power unit for operation.

Taxiing Precautions

1. Keep use of landing lights while taxiing to a minimum; they burn out quickly. If needed, use the lights continuously. They burn out more quickly if turned off and on than if they are left on in taxiing. If possible, use only one light, as they require considerable current. Remember landing lights are bright and may blind ground crew men helping you to park. However, don't hesitate to use both lights if you really need them.

Limit use of recognition lights with resin lenses to 10 seconds ground operation.

2. Make frequent checks of wheels and tires, using flashlights if landing gear inspection lights are not installed.

3. Using your flashlight, check cowling for signs of engine roughness.

4. When taxiing close to obstructions or parked aircraft, see that members of the ground crew walk ahead of each wing and direct taxiing by means of light signals.

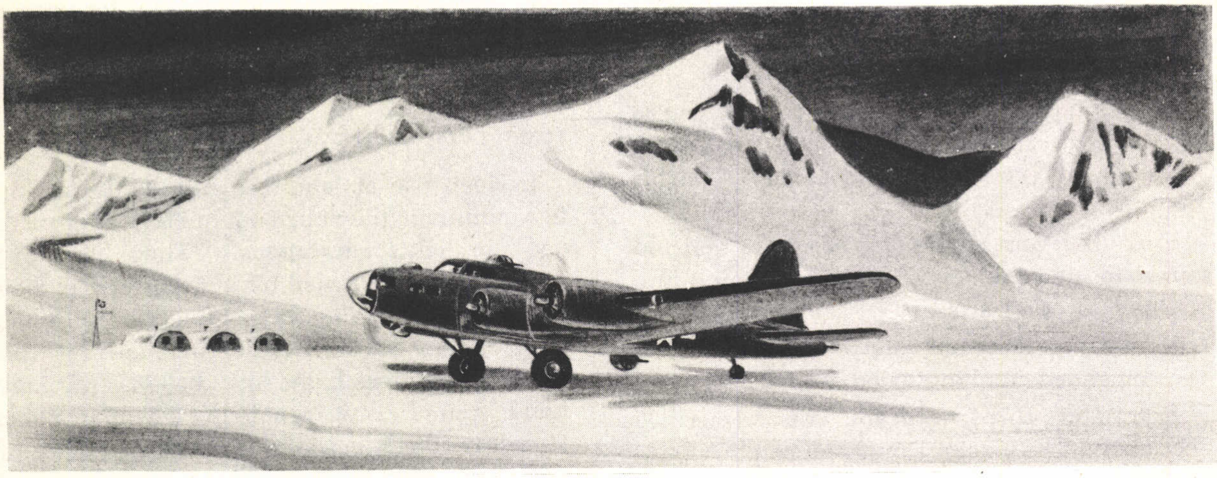
5. Be particularly careful in judging distance from other taxiing aircraft. Sudden closure of distance is difficult to notice at night.

6. In case of failure or weakening of brakes, stop immediately and have the airplane towed in to the line. Faulty brakes are always hazardous. They are certain to cause accidents when taxiing at night. Check hydraulic pressure at least every 30 seconds.

LANDING GEAR, LANDING LIGHT AND WING FLAP SWITCHES ARE CLOSE TOGETHER!

Get the right one.

COLD WEATHER OPERATION



Winter operation presents seasonal headaches in the operation and maintenance of the B-17 as it does in any other airplane.

Unless ground temperatures are below —23°C, no special procedures other than oil dilution are necessary so far as the pilot is concerned. Below this temperature, ground heaters must be used to preheat the engines and instruments, or warm hangar space must be available. (For detailed Winterization Instructions and Operation, see Technical Orders No. 01-20EF-51 and No. 00-60-3 and the PIF.)

Preheating.—Preheating is necessary under extreme cold weather conditions. Ground heaters are available for this purpose.

1. Cabin Compartment—When temperature is below —29°C it is necessary to heat the instrument panel to insure proper functioning of the instruments. Follow the prescribed procedure, utilizing openings in the nose and the bottom exit door.
2. Preheat propeller domes and engine front housing.
3. Preheat engine accessory section.
4. Thaw tailwheel assembly, if necessary.
5. Thaw control surface hinges.

Oxygen Equipment.—Operate all oxygen valves carefully in cold weather, opening and closing them slowly. (Rapid opening may cause sudden pressure and an explosion.)

Frost Prevention on Windows.—Leave opening in cockpit to permit air circulation, thus preventing frosting of windows.

Brakes.—When parking brakes have been in the "OFF" position for any length of time, the expander tubes stiffen in the contracted position. If pressure is applied suddenly, the expander tubes can be ruptured easily.

1. Have heat applied to brake drums if you think that the brakes are frozen.
2. Upon the first use of brakes, apply pressure gently. Do not apply full pressure until a number of light applications have been made.
3. While taxiing, if you suspect that moisture or water is present in the brakes, exercise the brakes more than usual. The extra heat thus generated will not only melt the snow or ice particles but will cause moisture to evaporate, leaving brakes practically dry. Be careful not to **overheat** brakes.

To Start Engines

1. Have the propellers pulled through at least 3 complete revolutions (9 blades). If difficulty is encountered in this operation, remove the lower spark plugs and clear the cylinders. Never back up the engine.

2. The proper use of engine primer will do much to facilitate engine starting in cold weather. Avoid overpriming, especially if first start is unsuccessful.

3. Leave mixture controls in "IDLE CUT-OFF" position.

4. Don't start on batteries if **auxiliary power** is available.

5. Start fuel booster pump.

6. Crack throttle to 800-1000 rpm.

7. Set primer to engine being started and operate to expel air from lines.

8. As starter is meshed, operate primer with rapid full strokes to atomize the fuel. Limit hand priming to amount necessary to keep engine running.

9. When engine fires, place mixture control in "AUTO-RICH" position. In extreme cold weather, it may be necessary to stand by with hand primer for a short time to keep engine running.

10. Return primer to "OFF" (down) position after all engines are started. Never leave primer plunger in the up position when not priming engine. This allows fuel to pass directly to engine selected.

11. Don't use the starter repeatedly (4 or 5 times) without allowing it to cool off.

Over-priming

Repeated attempts to start the engine with the use of prime may result in oil being washed off the cylinder walls by the priming gasoline. Don't overprime; normally five or six strong strokes while energizing and meshing furnish all the gasoline the engine can use.

You may have to use the primer to keep the engine running after it has started, but again, be careful about overpriming.

If the engine stops after the mixture control has been moved out of the "IDLE CUT-OFF" position, move the mixture control to "IDLE CUT-OFF" at once to keep the carburetor from overflowing and fuel from flowing to the blower-drain section of the engine.

If the engine has been overprimed or fails to start after several attempts:

1. Shut off the ignition switch. Place the throttle in the full open position. Have the propeller pulled through by hand to clear the engine of fuel.

2. Repeat starting procedure.

3. If several attempts at starting prove unsuccessful, locate cause of the trouble by consulting the Handbook of Service Instructions.

Oil Dilution After Starting

Follow the normal engine-starting procedure without regard for the oil dilution system. After starting, if oil pressure (a) is too high, (b) is fluctuating, or (c) drops as rpm is increased, this may indicate that heavy viscous oil is in the system. **The condition can be corrected by pushing the oil dilution switches several times.**

Use this method with caution, and only when extreme weather conditions and lack of time do not permit normal engine warm-up. Remember that it is possible to cause engine failure by supplying the engine oil pump with pure gasoline.

If dilution is used during the warm-up, keep a close check on oil pressure during the warm-up and takeoff to guard against overdilution. (See "Oil Dilution.")

Warm-up

1. Cowl flaps open for ground operation.

2. Check oil pressure. If there is no oil pressure indication within 30 seconds after starting shut down engine and investigate.

3. Idle engines at 900 and 1000 rpm until oil temperature rises to 40°C.

4. Operate oil regulated turbo controls slowly through their entire range several times after engines have warmed up. Proper functioning of turbo regulator depends on flow of engine oil through the regulator. It is imperative that cold oil in the regulator be replaced by warm engine oil. Otherwise, closed waste gate and runway turbo may result on takeoff.

5. Operate propeller controls slowly through their entire range several times after engine oil reaches desired temperature. Proper propeller functioning depends on flow of engine oil through governor and propeller dome.

OIL DILUTION

Oil dilution is simply the introduction of gasoline into the engine oil supply to thin the oil, making starting of the engine easier in cold weather. Engine oil should be diluted before stopping the engines when it is suspected that the outside air temperature will drop below 5°C during the period the engine is to be stopped.

System—The system consists of 4 electric solenoid-operated oil dilution valves, each located on the front of its respective engine firewall. Four toggle switches are on the copilot's control panel. A fuel line from the carburetor connects to the Y oil drain valve, also a line from the dilution valve to the fuel pressure gage. Turning the oil dilution switch "ON" permits gasoline to flow through the valve into the oil line to circulate through the entire engine oil system. Engines must be running before dilution can be accomplished.

Procedure

1. Idle engines until oil temperature drops to approximately 50°C.
2. Run engines at 1000 to 1200 rpm for dilution.
3. Maintain oil temperatures at less than 50°C and an oil pressure above 15 lb. sq. in. If oil temperature rises above, or oil pressure falls below these limits, stop engines, allow to cool, and continue dilution.
4. If the airplane has an automatic dilution switch installed, simply dilute as instructed.

Anticipated Lowest Outside Temperature	Dilution Time in Minutes—One Period
4° to —12° C	2 minutes
—12° to —29° C	5 minutes
—29° to —46° C	7 minutes

5. If the plane has the manual dilution switch, hold the switch "ON" for the period shown in the table; release the switch only after engine has been stopped.

For each 5°C below —46°C, add one minute to the time given.

6. Proper operation of the dilution system is indicated by considerable drop in fuel pressure.
7. If it is necessary to service oil tanks, split the dilution period in half and service between the 2 periods.
8. Near the completion of the final dilution period, depress the propeller feathering button for 2 to 4 seconds, or a maximum change of 400 rpm, and pull out. Repeat several times.
9. Toward the end of final dilution period, operate oil regulated supercharger controls several times from low to high boost positions, taking 8 to 10 seconds for this procedure. This insures dilution of oil in turbo regulator. (The procedure is unnecessary on airplanes equipped with electronic regulator.)

Whenever engines have been previously diluted and the airplane has not been flown, operate the engines for at least 30 minutes with oil temperature above 50°C before attempting **full dilution.** If a short ground run-up is made, the engines should be rediluted by reducing the dilution period accordingly. For instance, assume that dilution time is 5 minutes for full dilution. If engine run-up time is 15 minutes, the dilution time will be 2½ minutes.

After several days layover, during which time the engines have been started and diluted several times, it is advisable to ground-run the engines for 30 minutes at normal temperatures before takeoff to evaporate the gasoline in the oil.

Avoid **overdilution.** It causes the engine scavenging system to break down, resulting in a complete loss of all engine oil in a short time. Overdilution may be evidenced by a spewing of oil out of the engine breather, and a considerable drop in engine oil pressure.

CARBURETOR ICE PREVENTION IN FLIGHT

An understanding of the theory of carburetor ice formation and elimination is an important item in every pilot's technical knowledge. Tests have shown that under the most favorable conditions an engine will stop completely within 3 minutes after the first indications of icing have appeared. All B-17G and most B-17F airplanes are equipped with carburetor air temperature thermometers and gages to assist the pilot in detecting icing. The thermometers are so located that they measure inlet air temperature before fuel vaporization takes place.

Causes of Icing

The formation of carburetor ice is directly dependent upon the temperature and relative humidity of the carburetor inlet air. For ice to form, it is necessary that the carburetor inlet air temperature be less than 15°C and that the relative humidity be 50% or more. The ice forms in the adapter section, and sometimes at the fuel nozzle, as a result of the temperature drop (sometimes as much as 18°C) induced by fuel evaporization.

Icing caused by fuel evaporization does not affect the throttle valve of the Bendix Stromberg carburetor used on the B-17 airplane, as fuel is injected between the valve and the engine. **Throttle** icing can occur, however, under the following conditions:

1. Carburetor air inlet temperatures between 7°C and 10°C.

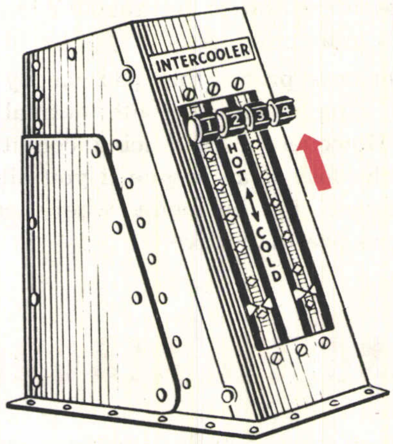
2. A relative humidity greater than 100%. (Rain drops or ice particles entering the air inlet.)

3. A throttle opening of less than 45°.

Icing is evidenced by rough engine operation, loss in manifold pressure, or abnormally high settings required of the throttle or turbo control levers to produce the desired manifold pressure.

Procedure for Ice Prevention

When operating under suspected icing conditions the following procedure is recommended:



1. Carburetor air filters on and intercooler shutters full closed ("HOT") for flight under 10,000 feet and landing.

2. Above 10,000 feet, it may be necessary to open the shutters in proportion to the altitude to avoid exceeding 38°C carburetor air temperature. Filters may be left on up to 15,000 feet with full-throttle engine operation, but not higher because serious overspeeding of the turbos will result if they do not have overspeed control.

Emergency Ice Removal

To remove ice in an emergency use the following procedure:

1. Turn filter on if below 15,000 feet.

2. Close intercooler shutters, but do not exceed 38°C carburetor inlet air except momentarily.

3. Open throttle fully and apply up to 4" turbo boost.

4. At or above 25,000 feet, close intercooler shutters only. Do not use filter or extra boost, because excessive turbo rpm will result unless turbos have overspeed control. Increase or decrease altitude to change the outside air temperature and reduce the amount of visible moisture such as fog, rain, snow, sleet, etc.

5. Generally, icing will not occur if the carburetor air inlet temperature is kept at 20°C or above.

If 38°C is not exceeded there will be no danger of detonation. It is more desirable to **prevent** formation of ice than to have to remove it in an emergency.

Experience proves that you can fly through severe icing conditions with normal precautions. However, a mild icing condition may cause the loss of an engine if you allow icing to progress to the point where corrective measures are ineffective.

ICING ON AIRCRAFT

Icing on aircraft in flight is a serious hazard. Ice accretion may occur at any temperature from near freezing down to more than —20°C when there is visible moisture in the atmosphere.

Avoid flying through icing zones when possible. Know how to remove ice when you do encounter it. Know your plane's limitations in icing conditions.

Ice on the Airplane

1. Reduces the efficiency of the airfoil, adds drag, and increases the stalling speed.

2. Makes your airplane difficult to control and maneuver.

3. Increases the drag of struts, fuselage, radio masts, landing gear, etc.

4. Increases the load.

5. Causes failure of or error in certain flight instruments.

Prepare for icing wherever there is visible moisture in the air at temperatures approaching or below the freezing level:

1. In freezing rains, in all frontal zones.

2. If there is sleet on the ground, somewhere aloft there is a layer of freezing rain, and above that a layer of air with temperature out of freezing range. Sleet itself is not considered too hazardous, although hail will cause immediate damage to wing and empennage leading edges, windshield and nose.

3. In cumulus clouds and others with vertical development, whenever they occur.

4. In orographic clouds, formed when moisture-laden air is forced upward over hills and mountain ranges.

5. Along fronts, in stratus and stratocumulus cloud formations.

Temperatures

Look for most severe icing when the temperature is between 0°C and —5°C. Icing may occur down to —20°C or colder. Low pressure areas on the airfoil may cause mild icing at temperatures a few degrees above freezing when other conditions are favorable to icing.

Propeller Anti-icer System

The propeller anti-icer system is designed to **prevent** the formation of ice on the propeller blades, **not to remove it.** Therefore, as a prerequisite to the satisfactory operation of the system, it is necessary to turn the propeller anti-icers "ON" upon encountering icing conditions and not after ice has formed.

Windshield Anti-Icer System

The pilot's windshields are kept free from ice by the use of windshield wipers in conjunction with an alcohol spray. The controls for

the system are on the sidewall above the pilot's control panel. Don't use the wipers on dry glass. This system also must be in operation **before** any ice has formed. It is designed to **prevent** ice, not to **remove** it.

Knock-out Windows

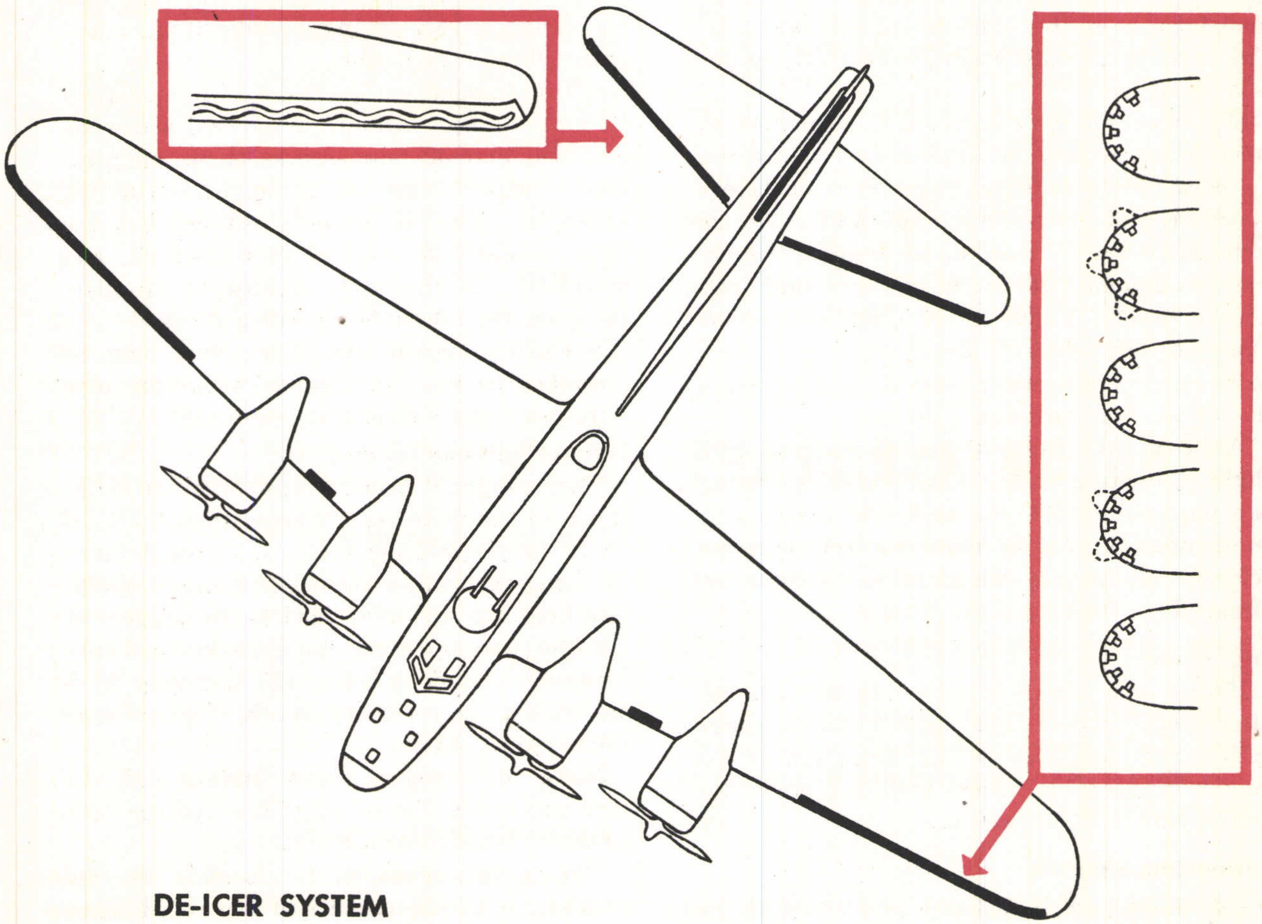
Knock-out panels on the pilot's and copilot's windshields provide visibility if windshields become covered with ice, snow, or rain. When opened, the panels swing up and are fastened to the top of the cockpit.

When you open the panels, expect a whistling sound and a slight inrush of air. The air blast is not strong enough to be objectionable, however, and opening the side window reduces both the air blast and the whistling noise.

De-icer System

The vacuum system of the B-17 operates both the de-icer boots and the flight instruments. Operation is obtained by means of 2 vacuum pumps mounted on the accessory case of the No. 2 and No. 3 engines. The system is so arranged that the pressure side of both pumps will inflate the de-icer boots while the vacuum side of one pump is operating to deflate them, and the vacuum side of the other pump is operating the flight instruments. In event of failure of either pump, use the remaining one to operate the instruments. That pump will also maintain the inflation of the boots. Their efficiency will be greatly reduced, however, because the boots have to depend upon their own elasticity for deflation.

The vacuum selector valve (control handle



DE-ICER SYSTEM

at the pilot's left) directs the suction flow from the instruments to either the No. 2 or No. 3 vacuum pump. The de-icer control valve (control at left of pilot's seat) operates the de-icer distributor valve and also connects the pressure from both vacuum pumps and suction from one pump to the distributor valve. The de-icer distributor valve controls the alternate distribution of vacuum and pressure to the various de-icer boots.

Efficient performance of the de-icing system depends upon correct usage. It is generally considered good practice to permit the deposit of ⅛-inch ice on the boots before starting inflation. Then operate the boots intermittently as new ice is formed. The cycle of operation depends upon the severity of the icing conditions. Sometimes ice forms so rapidly that continuous operation of the boots is necessary. Watch continuous operation closely, as new ice may form over the cracked ice on the boots. The tubes then will pulsate ineffectively under a layer of ice.

Under conditions conducive to formation of smooth ice, it may be undesirable to use the de-icers. Glaze usually forms smooth layers of ice around the leading edges and conforms to their contour. Unless the ice becomes rough, the aerodynamic efficiency of the airfoil may not be greatly impaired. A ridge of ice left along the aft edges of the boots can have a more detrimental effect than the ice covering the entire leading edge.

Although the stalling speed changes only slightly, landing with de-icer boots operating is a poor policy. When a stall does occur with boots operating, it is more violent, and recovery requires a considerable increase in airspeed.

Pitot Heater

Before entering an icing condition turn the pitot heater switch on the pilot's control panel "ON." This will prevent the formation of ice in the pitot tube which would render the entire pitot system useless.

During Takeoff

Never take off with snow, ice or frost on the wings. Even loose snow cannot be depended upon to blow off, and a thin layer is sufficient to cause loss of lift and abnormal flying characteristics.

1. Where landing or taking off on a narrow strip of clear ice, crosswinds are particularly dangerous. Lack of traction causes loss of maneuverability. If the wind is gusty, the airplane may be blown completely off the icy runway before you can regain control.

2. If deep, heavy snow interferes with the takeoff but permits the airplane to be taxied, move slowly up and down the takeoff course several times to pack down a runway before attempting the actual takeoff. The depth and hardness of the snow determine whether takeoff or landing is practicable.

3. Regardless of outside temperature, always take off with cowl flaps open. The hazard of taking off with partially closed cowl flaps is too great, and the possibility of an engine cooling off excessively during the takeoff and rated power climb is negligible.

4. If necessary, you can take off immediately after oil dilution without the normal warm-up, provided that oil temperature is up, oil pressure is steady, and the engines are running smoothly. Cold oil properly diluted has the same viscosity as heated, undiluted oil, and therefore has the same ability to circulate and properly lubricate aircraft engines.

5. During takeoff the intercoolers may be turned on partially to prevent carburetor icing or to insure smooth engine operation.

During Flight and Landing

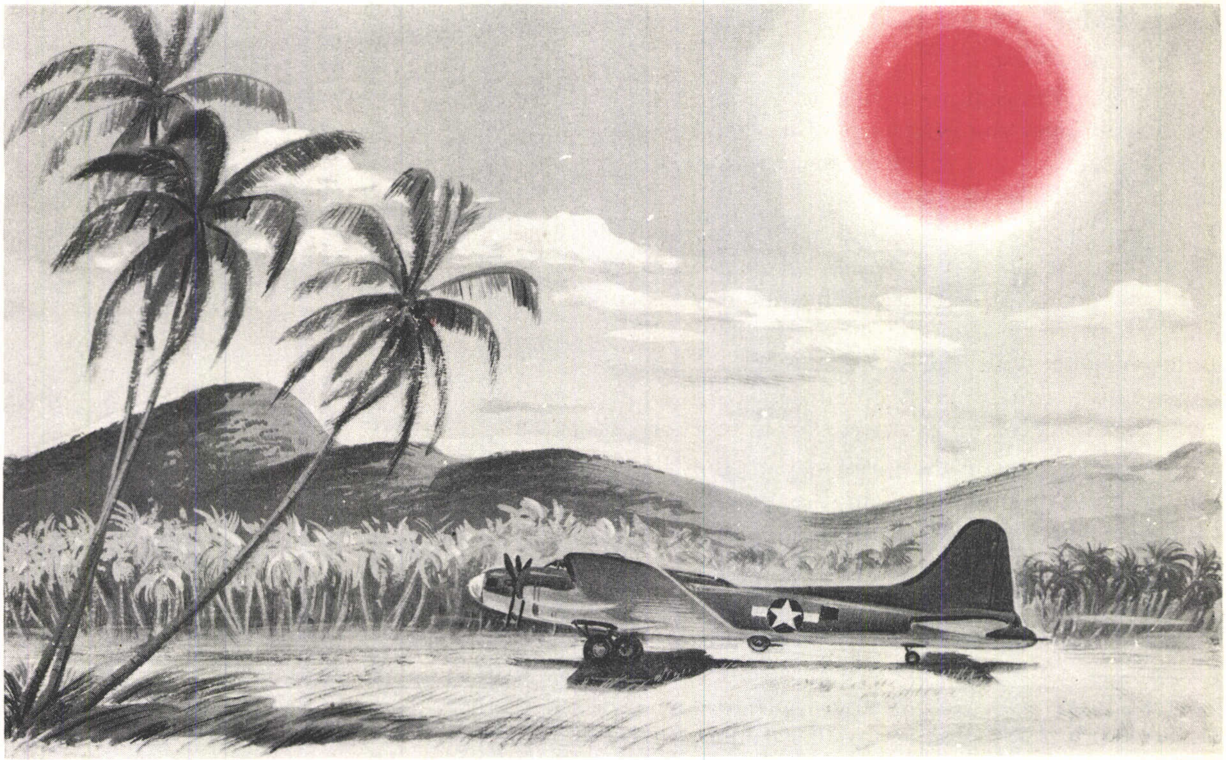
During flight, it is advisable to maintain cylinder-head temperatures not lower than 150°C. If the temperature drops below 125°, rough operation may result. Closed cowl flaps and lean mixture help hold cylinder-head temperatures up.

When there is danger that cylinder-head temperatures may drop below 125°C during landing, make a power-on approach, if possible, to keep engines warm.

Make your approach and landing with the carburetor air filters on. This reduces the tendency toward carburetor icing.

During the approach for landing in cold weather, don't idle engines at low speed. They should be run up and checked frequently.

HOT WEATHER TIPS



Before Flight

1. Starting in hot weather requires less priming than starting under normal operating conditions.
2. Although outside air temperature is high, don't take off until oil temperature and oil pressure readings are normal.
3. Keep warm-up time and engine run-up time to a minimum. Run-up time for each engine should never exceed 30 seconds.
4. Always have cowl flaps open for all ground operation and for takeoff.
5. Remember, takeoff distances will be longer in hot weather.
6. While the airplane is on the ground, leave opening in fuselage for ventilation.
7. Use brakes as little as possible.

In Flight

1. Climb at not less than specified climbing speed (140 mph); lower climbing speeds will cause higher engine temperatures.
2. Low-altitude flying also will cause higher engine temperatures.
3. True stalling speed is greater in hot weather because the air is not as dense, but the indicated stalling speed is the same.
4. Don't expect to land in the same distance in hot weather as in cool weather. Indicated airspeed is the same, but groundspeed is increased because of the thinner air.
5. In hot weather, watch cylinder-head temperature closely and regulate it with cowl flaps.

OXYGEN

Your airplane was designed to operate just as well at high altitude as at low altitude.

Your body wasn't!

All organisms require oxygen to support life. At ground level you get plenty of oxygen from the surrounding air, which is packed down by the weight of the air above it.

As you go up there is less air above you. Therefore the air you breathe becomes thinner, your body is getting insufficient oxygen, and you begin to lose efficiency. At some altitude—varying with the individual—you'll become unconscious, and then, unless you get some extra oxygen quick . . . that's all, brother!

Remember, when the pressure of the air you're breathing is less than the normal atmospheric pressure of 10,000 feet, you need extra oxygen.

Therefore, your airplane has an oxygen system to meet the requirements of your body and allow you to function normally.

The equipment is excellent, simple to operate, and safe for flights up to 40,000 feet. **But it is not safe unless you understand it thoroughly and strictly observe the rules regarding its use.** You can't take short cuts with oxygen and live to tell about it!

The lack of oxygen, known as anoxia, gives no warning. If it hits you, you won't know it until your mates revive you from unconsciousness, if they can. Therefore, you must check the condition and operation of your equipment with extreme care, and continue to check it regularly as often as possible during flight.

Your oxygen mask is an item of personal issue. Take care of it. It's as important as your life.

Before you use the mask in flight, have it fitted carefully by your personal equipment officer, or his qualified assistants. They will see that you have the right size, that it fits perfectly, and that the studs to hold it are properly fixed to your helmet.

Bring it in for re-checking whenever necessary. The straps will stretch slightly after a period of use. It's a good idea to have the fit re-checked regularly whether you think it needs it or not.

Keep your mask in kit when not in use.

Draw the mask before each mission. Return it to the supply room afterward. Equipment personnel will check it for repair and cleaning. But don't assume that this procedure relieves you of the responsibility of your own regular inspection and care of the mask.

Before each mission, make the following checks on your mask:

1. Look the mask and helmet over carefully for worn spots or worn straps, loose studs, improper seating of exhalation valve, or evidence of deterioration in facepiece and hose.

2. Put the mask on carefully. Slip the edges of the facepiece under the helmet. Adjust the straps, if necessary, to get a good fit.

3. Test for leak. Hold your thumb over the end of the hose and breathe in **gently**. The

mask should collapse on your face, with no air entering. Don't inhale strongly because the mask would seal anyway in that case, even with a leak.

4. See that the rivets in the mask are in position.

5. See that the neck where hose and mask meet is rigid, and that the bakelite ring is not broken.

6. Clip the end of the regulator hose to your jacket in such a position that you can move your head around fully without twisting or kinking the mask hose or pulling on the mask hose or pulling on the quick-disconnect. Get the personal equipment section to sew a tab on your jacket at the proper spot.

7. See that the gasket is properly seated on the male end of the quick-disconnect fitting between mask and regulator hose. Plug in the fitting and **test the pull.** You can make a temporary adjustment in a loose old-type fitting by spreading the prongs with a knife blade. The new-type fittings are not likely to give trouble, but if they do they must be replaced; they cannot be adjusted.

General Tips: Vapor in your breath will freeze in the mask at extremely low temperatures. If you detect freezing, squeeze the mask to prevent ice particles from clogging the oxygen inlet.

Don't let anyone else wear your mask except in emergencies.

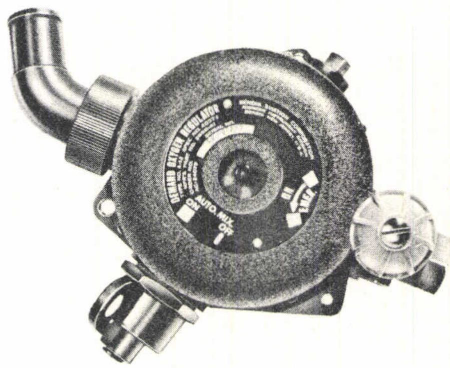
Keep it in the kit between flights, and keep it clean by washing with mild soap and plenty of water.

Report anything wrong with the functioning or condition of the mask when you turn it in after a flight.

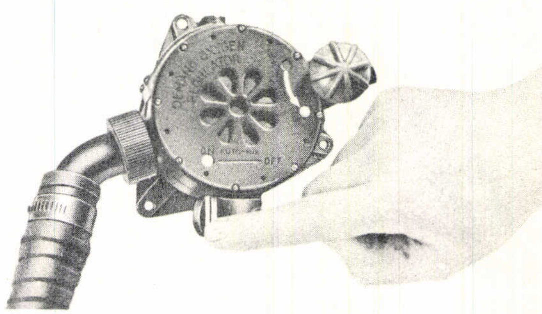
Oxygen Regulator

A demand regulator (sometimes called "diluter-demand") is mounted at each station in the airplane. You may find any one of several models of demand regulators in your plane. They look slightly different, but the principle of operation is the same in all.

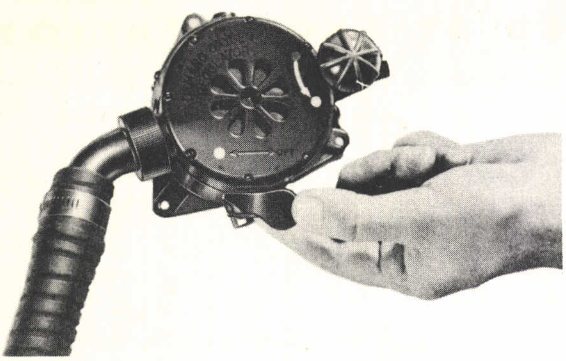
A demand regulator is one that furnishes oxygen on demand, or only when you inhale. It furnishes no oxygen when you exhale. Obviously, this is a more economical principle than a continuous flow of oxygen.



Pioneer Regulator



Aro Regulator. Auto-mix "ON" (NORMAL OXYGEN")



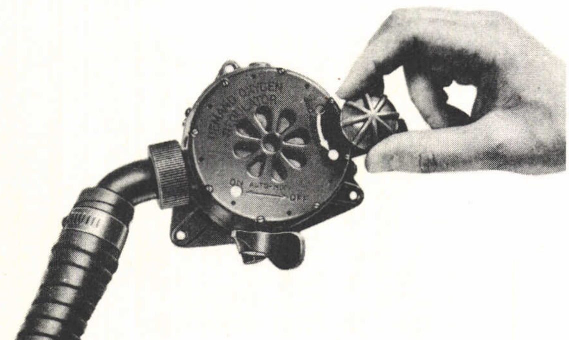
Aro Regulator. Auto-Mix "OFF" ("100% OXYGEN")

The regulator has an auto-mix mechanism controlled by a lever on the side of the cover. **The lever should be in the "ON" position (marked "NORMAL OXYGEN" on some regulators) at all times** when the system is in use (except in certain emergencies). When the lever is in the "ON" position, oxygen furnished below 30,000 feet is mixed with air. The mixture is controlled automatically by an aneroid to furnish the correct amount of oxygen which your body requires for a given altitude. Above approximately 30,000 feet the air inlet closes and you get 100% oxygen, although the lever in the regulator is still in the "ON" position.

With the lever in the "OFF" position, (marked "100% OXYGEN" on some regulators) 100% oxygen is furnished. This operation wastes oxygen.

When breathing oxygen, **never turn the lever to "OFF" except in the following cases:**

1. To give 100% oxygen to a wounded man below 30,000 feet.
2. If poison gas is present in plane.



Operation of Emergency Valve

3. If the airplane commander prescribes breathing 100% oxygen all the way up to high altitude as a protection against the bends.

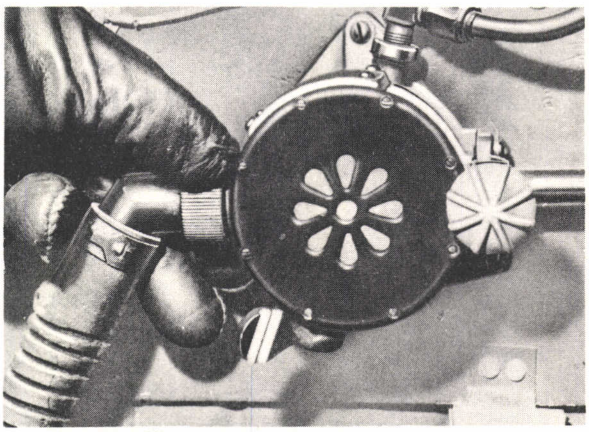
To operate the emergency valve, break the safety wire and turn the red knob on the intake side of the regulator in the direction indicated on the regulator face. **Caution: Never pinch the mask hose or block the oxygen flow when the emergency valve is turned to "ON." This action breaks the regulator diaphragm.**

Turning emergency valve to "ON" causes the oxygen flow to bypass the demand mechanism and to flow continuously into the mask. It is extremely **wasteful of oxygen.** Leaving the valve "ON" bleeds the whole airplane oxygen system in a short time.

Never turn the emergency valve to "ON," except:

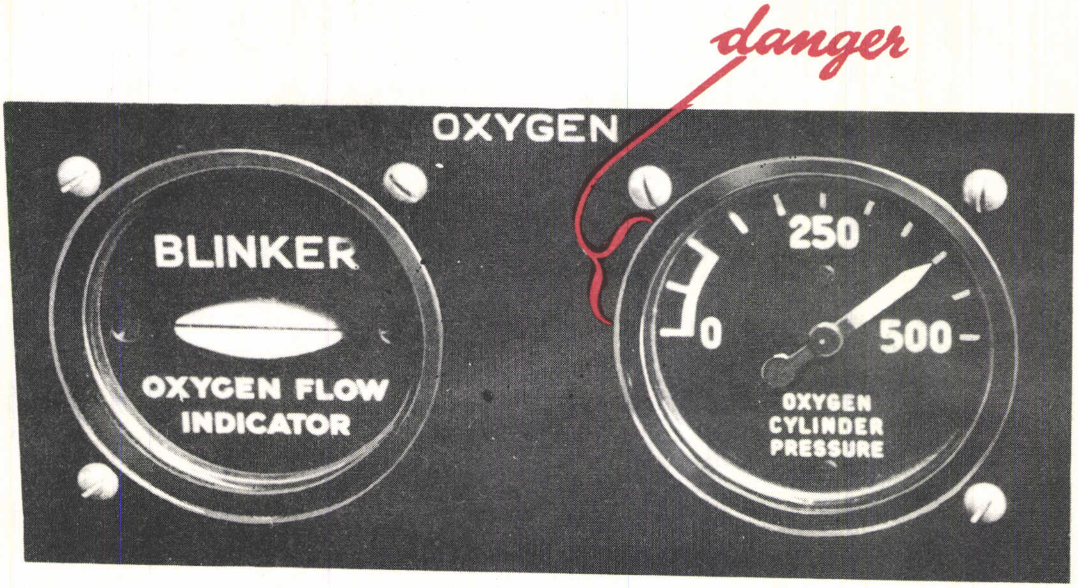
1. To revive a crew member.
2. In cases of excessive mask leakage.
3. When you have to take off your mask temporarily, for example, to blow your nose, vomit, or spit. In those cases unhook one side of the mask and hold it as close to your face as possible.

Make the following checks before each flight:



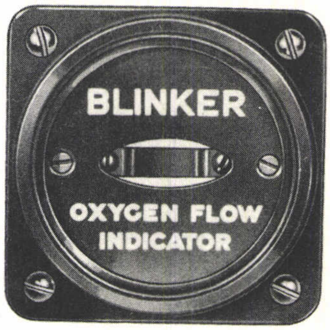
1. Check the tightness of the knurled collar. It should be so tight that the movement of the regulator hose will not turn the elbow.
2. Examine the emergency valve knob. It should be closed tightly and safetied with light safety wire.

OXYGEN PANEL LOCATED AT EACH STATION

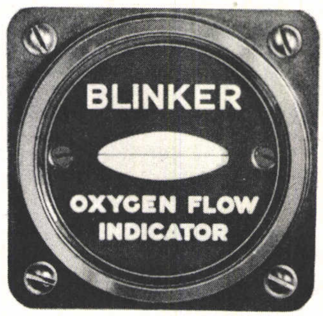


Flow Indicator

Pressure gage



Blinker flow indicator, open



Blinker flow indicator, closed

Flow Indicator

The flow indicator on the oxygen panel winks open and shut as the oxygen flows during breathing. The blinker may not operate normally at ground level with the auto-mix lever "ON" (NORMAL OXYGEN). Therefore, to test it, plug in your mask before flight, turn the auto-mix lever to "OFF" ("100% OXYGEN") and see that the blinker works as you breathe.

Be sure to move the lever back to "ON" ("NORMAL OXYGEN") before flight.

The blinker does not work when the emergency valve is "ON." It works only when you have the mask on and are breathing.

(Note: Some airplanes have ball-in-cylinder flow indicators.)

Watch your flow indicator during flight. It is the only indication you have that the oxygen is flowing regularly. If flow indication stops, use your portable equipment and plug in at another station if possible.

Pressure Gage

Before flight, check the pressure gage on your panel. When the system on your plane is full the pressure should be between 400 and 425 lb. sq. in. Check the gage also against the gages at other stations. There may be some variation between stations because of different tolerances in the gages, but if yours is more than 50 lb. sq. in. off the others, investigate.

The regulator does not work properly when the pressure gets below 50 lb. sq. in. If you can't get downstairs at that time, use your portable equipment until you can descend.

Walk-around Equipment

There is a walk-around bottle at each crew station in the airplane. There are several types of these: the A-4 and A-6 cylinders, which clip on to your clothing, and the larger D-2 cylinder, which has a canvas sling with shoulder strap. All have gages and regulators.

Before each flight, check to see that your walk-around bottle is within easy reach. Look at the gage. If the pressure is more than 50 lb. sq. in. under the pressure of the airplane system, recharge the bottle.

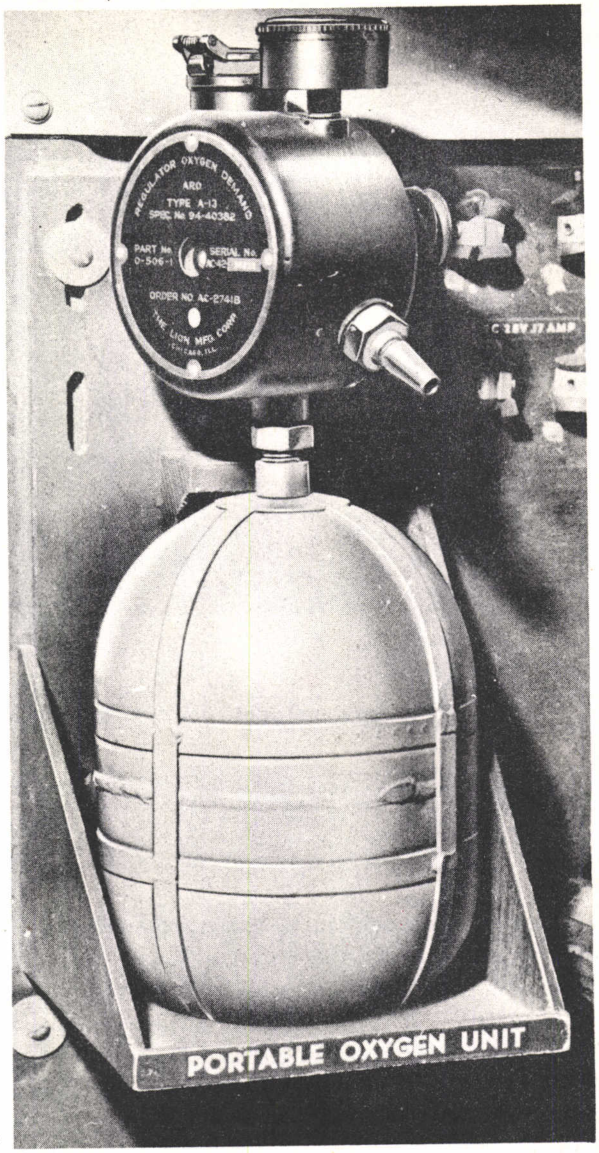
There is a recharging hose at each station. Snap the hose fitting on the nipple of the regulator. Push it home until it clicks and locks. When the bottle has filled to the pressure of the plane system, turn the hose clamp clockwise and remove hose fitting. You can carry out this operation while your mask is plugged into the bottle you are filling.

Always use a walk-around bottle if you have to disconnect from the airplane system. Hold your breath while you are switching to the bottle.

The duration of the walk-around oxygen supply is variable. Don't depend on it to last very long, regardless of what you have heard about the capacity.

Keep watching the gage, and recharge the bottle when it needs it.

Always recharge walk-around equipment after use.



A-4 walk-around bottle on bracket at airplane station

Bailout Cylinders

The emergency bailout cylinder is a small high-pressure oxygen cylinder, with a gage attached, which furnishes a continuous flow of oxygen.

The cylinder comes in a heavy canvas pocket provided with tying straps. Have this pocket sewed and tied securely to the harness of your parachute. The new flying suits have a zipper pocket on the left thigh to hold this bottle.

Before flight, check to see that the pressure of the cylinder is at 1800 lb. sq. in. If you have to bail out at a high altitude, securely plug the bayonet connection on the hose into the adapter on your mask, open the valve, and then disconnect your mask from the plane supply.

Keep bailout cylinder hose plugged into mask

Remember

YOUR OXYGEN EQUIPMENT IS YOUR LIFE

OXYGEN DURATION

The B-17 has four separate oxygen systems. They are manifolded together and under normal conditions the pressure in all systems remains equalized as oxygen is used up. However, sudden loss of pressure in any system seats check valves which isolate that system from the rest.

If a cylinder is shot out, you lose only the supply in that cylinder, because each cylinder is equipped with check valves.

In computing supply of oxygen left, be sure to deduct cylinders shot out. For example, if one of a bank of four cylinders is lost, one-fourth of the time of available oxygen (as computed from the gage and chart) is lost. (There is no immediate drop of pressure shown on the gages when a cylinder goes out.)

*MAN HOURS OF AVAILABLE OXYGEN

BLACK FIGURES INDICATE AUTO-MIX "ON" ("NORMAL OXYGEN") **RED FIGURES INDICATE AUTO-MIX "OFF" ("100 % OXYGEN")**

CAUTION—The auto-mix in the "OFF" position rapidly diminishes the available oxygen supply. Do not use this position unless it is necessary to get pure oxygen!

GROUP I (5 G-1 Cylinders)
Pilot, Navigator and Top Turret Filler

ARO REGULATORS
TYPE A-12

Gage Pres. / Alt. Ft.	400	350	300	250	200	150	100	50
	41.5	35.6	29.4	23.6	17.8	12.0	5.8	E
40,000	41.5	35.6	29.4	23.6	17.8	12.0	5.8	
	29.5	25.3	20.9	16.8	12.6	8.5	4.0	M
35,000	29.5	25.3	20.9	16.8	12.6	8.5	4.0	
	21.5	18.5	15.2	12.2	9.2	6.0	3.0	E
30,000	22.0	18.9	15.6	12.5	10.4	6.2	3.0	
	16.5	14.1	11.5	9.0	7.0	4.7	2.0	R
25,000	21.0	18.0	14.9	11.9	9.0	6.0	2.9	
	13.0	11.1	9.2	7.4	5.5	3.7	1.5	G
20,000	23.5	20.2	16.6	13.3	10.1	6.8	3.2	
	10.0	8.6	7.0	5.7	4.0	3.9	1.4	E
15,000	28.5	24.5	20.2	16.2	12.2	8.2	3.9	
	8.0	6.8	5.6	4.5	3.4	2.3	1.1	N
10,000	48.5	41.7	34.4	27.6	20.8	14.0	6.7	
	6.5	5.5	4.6	3.7	2.8	1.8	1.0	C
5,000	—	—	—	—	—	—	—	
	5.5	4.7	3.9	3.1	2.3	1.5	0.7	Y
S. L.	—	—	—	—	—	—	—	

PIONEER REGULATORS
TYPE A-12

Gage Pres. / Alt. Ft.	400	350	300	250	200	150	100	50
	41.5	35.6	29.4	23.6	17.8	12.0	5.8	E
40,000	41.5	35.6	29.4	23.6	17.8	12.0	5.8	
	29.5	25.3	20.9	16.8	12.6	8.5	4.0	M
35,000	30.0	25.8	21.3	17.1	12.9	8.7	4.2	
	21.5	18.5	15.2	12.2	9.2	6.0	3.0	E
30,000	22.5	19.3	15.9	12.8	9.6	6.5	3.1	
	16.5	14.1	11.5	9.0	7.0	4.7	2.0	R
25,000	22.0	18.4	15.6	12.5	9.4	6.3	3.0	
	13.0	11.1	9.2	7.4	5.5	3.7	1.5	G
20,000	39.0	33.5	26.6	22.2	16.7	11.3	5.4	
	10.0	8.6	7.0	5.7	4.0	3.9	1.4	E
15,000	38.0	32.6	26.9	21.6	16.3	11.0	5.3	
	8.0	6.8	5.6	4.5	3.4	2.3	1.1	N
10,000	37.5	32.2	26.6	21.3	16.1	10.8	5.2	
	6.5	5.5	4.6	3.7	2.8	1.8	1.0	C
5,000	28.5	24.5	20.2	16.1	12.2	8.2	3.9	
	5.5	4.7	3.9	2.3	2.3	1.5	0.7	Y
S. L.	30.0	25.8	21.3	17.1	12.9	8.7	4.2	

GROUP II (4 G-1 Cylinders)
Copilot, Bombardier and Top Gunner

ARO REGULATORS, TYPE A-12

Gage Pres. / Alt. Ft.	400	350	300	250	200	150	100	50
	33.2	28.6	23.6	19.0	14.2	9.6	4.6	E
40,000	33.2	28.5	23.6	18.9	14.2	9.6	4.6	
	23.6	20.2	16.8	13.4	10.2	6.8	3.4	M
35,000	23.6	20.3	16.7	13.4	10.1	6.8	3.3	
	17.2	14.8	12.2	9.8	7.4	5.0	2.4	E
30,000	17.6	15.1	12.5	10.0	7.6	5.0	2.4	
	13.2	11.2	9.2	7.4	5.6	3.8	1.8	R
25,000	16.8	14.4	11.9	9.6	7.2	4.8	3.3	
	10.4	9.0	7.4	6.0	4.4	3.0	1.4	G
20,000	18.8	16.2	13.3	10.7	8.1	5.4	2.6	
	8.0	6.8	5.6	4.6	3.4	2.4	1.2	E
15,000	22.8	19.6	16.2	13.0	9.9	6.6	3.2	
	6.4	5.4	4.6	3.6	2.8	1.8	0.8	N
10,000	38.8	33.4	27.5	22.1	16.7	11.2	5.4	
	5.2	4.4	3.6	3.0	2.2	1.4	0.8	C
5,000	—	—	—	—	—	—	—	
	4.4	3.8	3.2	2.4	1.8	1.2	0.6	Y
S. L.	—	—	—	—	—	—	—	

PIONEER REGULATORS, TYPE A-12

Gage Pres. / Alt. Ft.	400	350	300	250	200	150	100	50
	33.2	28.6	23.6	19.0	14.2	9.6	4.6	E
40,000	33.2	28.5	23.6	18.9	14.2	9.6	4.6	
	23.6	20.2	16.8	13.4	10.2	6.8	3.4	M
35,000	24.0	20.6	19.0	13.7	10.3	6.9	3.3	
	17.2	14.8	12.2	9.8	7.4	5.0	2.4	E
30,000	18.0	15.5	12.8	10.2	7.7	5.2	2.5	
	13.2	11.2	9.2	7.4	5.6	3.8	1.8	R
25,000	17.6	14.7	12.5	10.0	7.6	7.1	2.4	
	10.4	9.0	7.4	6.0	4.4	3.0	1.4	G
20,000	31.2	26.8	22.1	17.8	13.4	9.0	4.3	
	8.0	6.8	5.6	4.6	3.4	2.4	1.2	E
15,000	30.4	26.1	21.6	17.3	13.0	8.8	4.2	
	6.4	5.4	4.6	3.6	2.8	1.8	0.8	N
10,000	30.0	25.9	21.3	17.1	12.9	8.7	4.2	
	5.2	4.4	3.6	3.0	2.2	1.4	0.8	C
5,000	22.8	19.6	16.2	13.0	9.8	6.6	3.1	
	4.4	3.8	3.2	2.4	1.8	1.2	0.6	Y
S. L.	24.0	20.6	17.0	13.7	10.3	7.0	3.3	

*Time shown is total man hours remaining. Divide by number of men using system.

*MAN HOURS OF AVAILABLE OXYGEN

BLACK FIGURES INDICATE AUTO-MIX "ON" ("NORMAL OXYGEN") **RED FIGURES INDICATE AUTO-MIX "OFF" ("100" % OXYGEN")**

NOTE: Each turret cylinder, Type F-1, will supply one man for approximately 2 hours at 30,000 feet, 2½ hours at 25,000 feet, 3 hours at 20,000 feet

ARO REGULATORS
TYPE A-12

GROUP III (6 G-1 Cylinders)
Bomb Bay, Radio Operator, Side Gunner, Tail Gunner, and Ball Turret Filler

Gage Pres. / Alt. Ft.	400	350	300	250	200	150	100	50
	49.8	42.8	35.4	28.4	21.4	14.4	7.0	
40,000	49.8	42.8	35.4	28.4	21.2	14.4	6.9	E
	35.4	30.4	25.0	20.2	15.2	10.2	5.0	
35,000	35.4	30.4	25.0	20.1	15.1	10.2	4.9	M
	25.8	22.2	18.2	15.6	11.0	7.4	2.8	
30,000	26.4	22.6	18.7	15.0	11.3	7.5	3.6	E
	19.8	16.8	13.8	11.2	8.4	5.6	2.8	
25,000	25.2	21.6	17.8	14.3	10.8	7.2	3.4	R
	15.6	13.6	11.0	8.8	6.6	4.4	2.2	
20,000	28.2	24.2	19.9	16.0	12.1	8.1	3.9	G
	12.0	10.4	8.6	6.8	5.2	3.4	1.6	
15,000	34.2	29.4	24.2	19.4	14.7	9.8	4.7	E
	9.6	8.2	6.8	5.4	4.2	2.8	1.4	
10,000	58.2	50.0	41.2	33.1	25.0	16.8	8.1	N
	7.8	6.6	5.6	4.2	3.4	2.2	1.2	
5,000	—	—	—	—	—	—	—	C
	6.6	5.6	4.6	3.8	2.8	1.8	0.8	
S. L.	—	—	—	—	—	—	—	Y

GROUP IV (3 G-1 Cylinders)
Radio Compartment (2 Outlets), Side Gunner and Tail Gunner

Gage Pres. / Alt. Ft.	400	350	300	250	200	150	100	50
	24.9	21.4	17.7	14.2	10.7	7.2	3.5	
40,000	24.9	21.4	17.7	14.2	10.7	7.2	3.5	E
	17.7	15.2	12.5	10.1	7.6	5.1	2.5	
35,000	17.7	15.2	12.5	10.1	7.6	5.1	2.5	M
	12.9	11.1	9.1	7.3	5.5	3.7	1.4	
30,000	13.2	11.3	9.4	7.5	5.7	3.8	1.8	E
	9.9	8.4	6.9	5.6	4.2	2.8	1.4	
25,000	12.6	10.8	8.9	7.2	5.4	3.6	1.7	R
	7.8	6.8	5.5	4.4	3.3	2.2	1.1	
20,000	14.1	12.1	10.0	8.0	6.1	4.1	1.9	G
	6.0	5.2	4.3	3.4	2.6	1.7	0.8	
15,000	17.1	14.7	12.1	9.7	7.3	4.9	2.4	E
	4.8	4.1	3.4	2.7	2.1	1.4	0.7	
10,000	29.1	25.0	20.5	16.6	12.3	8.4	4.0	N
	3.9	3.3	2.8	2.1	1.7	1.1	0.6	
5,000	—	—	—	—	—	—	—	C
	3.3	2.8	2.3	1.9	1.4	0.9	0.4	
S. L.	—	—	—	—	—	—	—	Y

PIONEER REGULATORS
TYPE A-12

GROUP III (6 G-1 Cylinders)

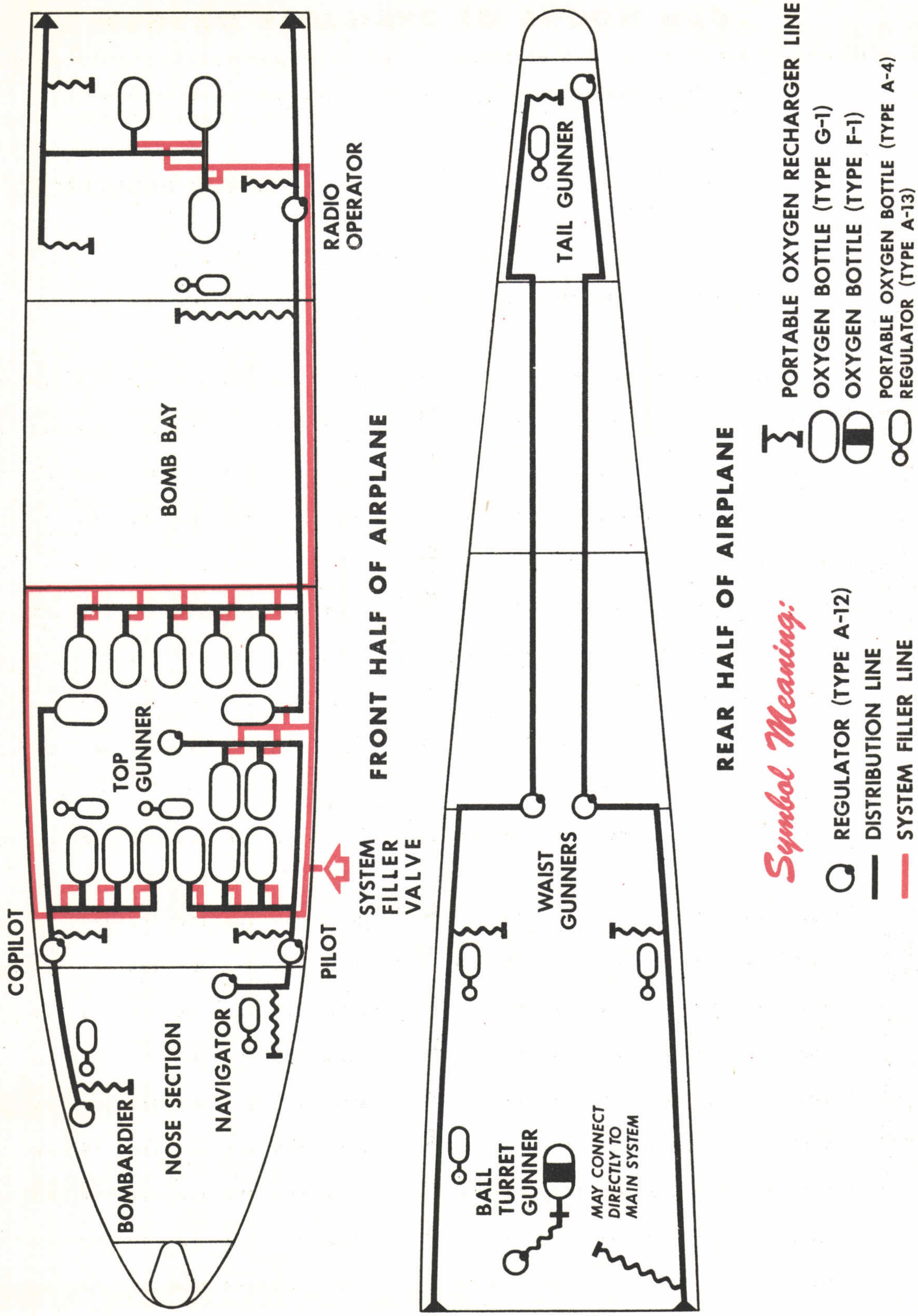
Gage Pres. / Alt. Ft.	400	350	300	250	200	150	100	50
	49.8	42.8	35.4	28.4	21.4	14.4	7.0	
40,000	49.8	42.8	35.4	28.4	21.3	14.4	6.9	E
	35.4	30.4	25.0	20.2	15.2	10.2	5.0	
35,000	36.0	30.9	25.5	20.5	15.4	10.4	5.0	M
	25.8	22.2	18.2	15.6	11.0	7.4	2.8	
30,000	27.0	23.2	19.1	15.3	11.5	7.8	3.7	E
	19.8	16.8	13.8	11.2	8.4	5.6	2.8	
25,000	26.4	22.0	18.7	15.0	11.3	7.6	3.8	R
	15.6	13.6	11.0	8.8	6.6	4.4	2.2	
20,000	46.8	40.2	33.1	26.6	20.1	13.5	6.5	G
	12.0	10.4	8.6	6.8	5.2	3.4	1.6	
15,000	45.6	39.1	31.7	25.9	19.5	13.2	6.3	E
	9.6	8.2	6.8	5.4	4.2	2.8	1.4	
10,000	45.0	38.7	31.9	25.6	19.3	13.0	6.3	N
	7.8	6.6	5.6	4.2	3.4	2.2	1.2	
5,000	32.2	29.4	24.2	19.4	14.7	9.9	4.5	C
	6.6	5.6	4.6	3.8	2.8	1.8	0.8	
S. L.	36.0	31.9	25.5	20.5	15.4	10.4	5.0	Y

GROUP IV (3 G-1 Cylinders)

Gage Pres. / Alt. Ft.	400	350	300	250	200	150	100	50
	24.9	21.4	17.7	14.2	10.7	7.2	3.5	
40,000	24.9	21.4	17.7	14.2	10.7	7.2	3.5	E
	17.7	15.2	12.5	10.1	7.6	5.1	2.5	
35,000	18.0	15.5	12.8	10.3	7.7	5.2	2.5	M
	12.9	11.1	9.1	7.3	5.5	3.7	1.8	
30,000	13.5	11.6	9.6	7.7	5.8	3.9	1.9	E
	9.9	8.4	6.9	5.6	4.2	2.8	1.4	
25,000	13.2	11.0	9.4	7.5	5.7	3.8	1.8	R
	7.8	6.8	5.4	4.4	3.3	2.2	1.1	
20,000	23.4	20.1	16.6	13.3	10.0	6.8	3.3	G
	6.0	5.2	4.3	3.4	2.6	1.7	0.8	
15,000	22.8	19.6	16.2	13.0	9.8	6.6	3.2	E
	4.8	4.1	3.4	2.7	2.1	1.4	0.7	
10,000	22.5	19.3	16.0	12.8	9.7	6.5	3.1	N
	3.9	3.3	2.8	2.1	1.7	1.1	0.6	
5,000	16.1	14.7	12.1	9.7	7.3	4.9	2.3	C
	3.3	2.8	2.3	1.9	1.4	0.9	0.4	
S. L.	18.0	15.5	12.8	10.3	7.7	5.2	2.5	Y

*Time shown is total man hours remaining. Divide by number of men using system.

OXYGEN SYSTEM FLOW



FORMATION

When you get into combat you will learn that your best assurance of becoming a veteran of World War II is the good, **well-planned,** and well-executed formation.

Formation flying is the first requisite of successful operation of the heavy bomber in combat. Groups that are noted for their proficiency in formation flying are usually the groups with the lowest casualty rates. Proper formation provides: controlled and concentrated firepower, maneuverability, cross-cover, precise bombing pattern, better fighter protection.

Heavy Bomber Formations

Formation flying in 4-engine airplanes presents greater problems than formation flying in smaller aircraft. The problems increase in almost direct proportion to the airplane's size and weight. In the B-17, relatively slower response to power and control changes require a much higher degree of **anticipation** on the part of the pilot. Therefore you must allow a greater factor of safety.

Violent maneuvers are unnecessary and seldom encountered. Close flying becomes an added hazard which accomplishes no purpose and is not even an indication of a good formation. Bear in mind that it is much more difficult to maintain position when flying with proper spacing between airplanes than with wings overlapping.

Safety first is a prerequisite of a good formation because a greater number of lives and a larger amount of equipment is in the hands of the responsible pilot in a large 4-engine airplane.

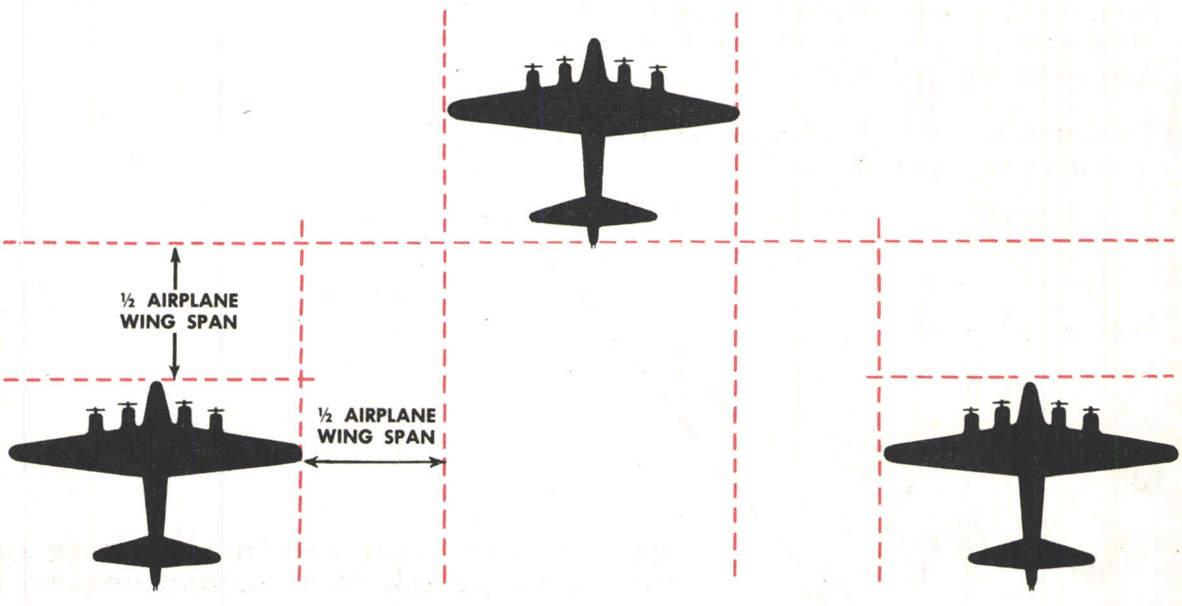
Clearance In Training Formations

When flying the Vee formation in training, aircraft will not be flown closer to each other than:

One-half airplane wing span from nose to tail;

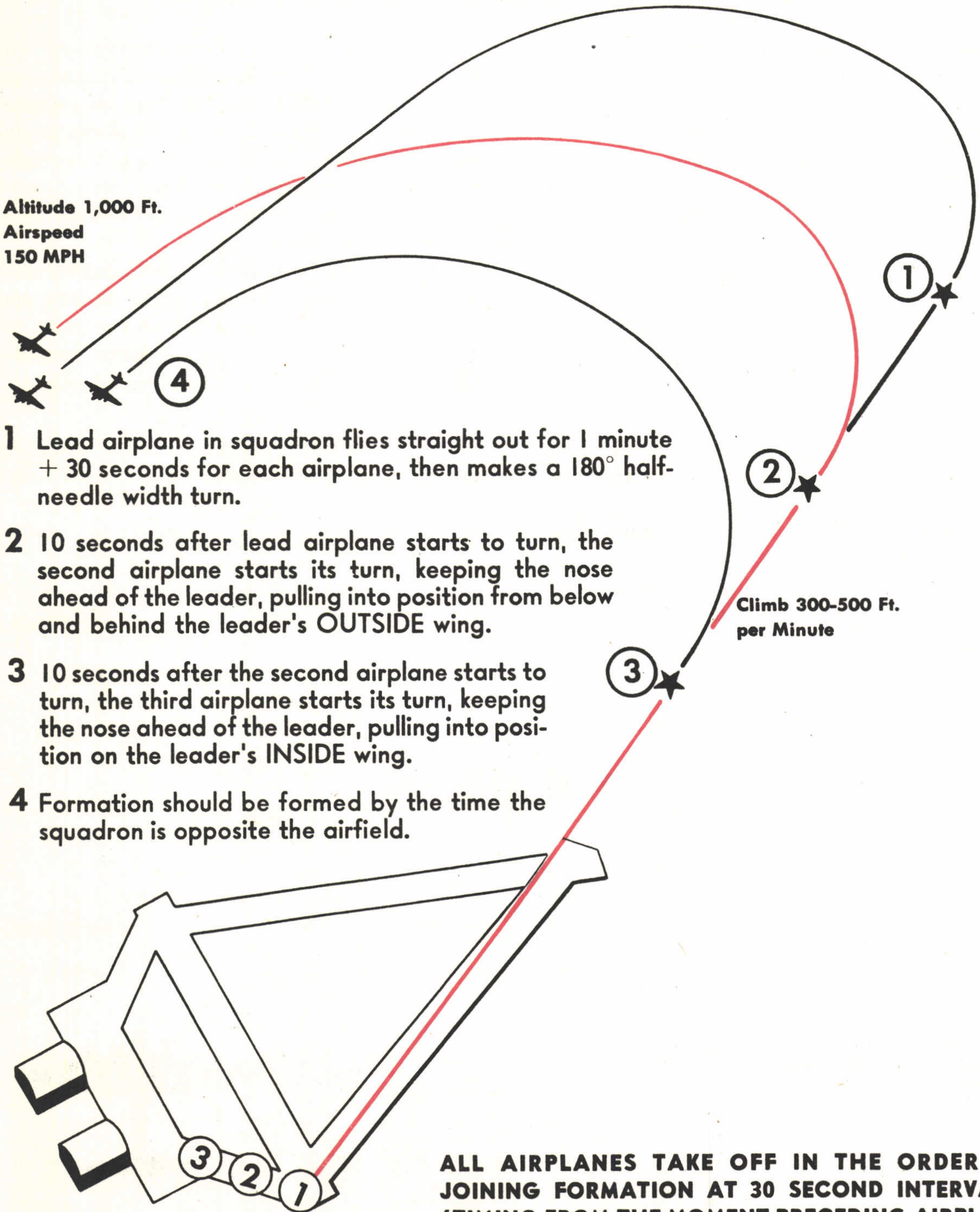
One-half airplane wing span from wingtip to wingtip;

One-half airplane wing span from top of airplane to bottom of airplane.



THE VEE FORMATION

SQUADRON FORMATION TAKEOFFS



1 Lead airplane in squadron flies straight out for 1 minute + 30 seconds for each airplane, then makes a 180° half-needle width turn.

2 10 seconds after lead airplane starts to turn, the second airplane starts its turn, keeping the nose ahead of the leader, pulling into position from below and behind the leader's OUTSIDE wing.

3 10 seconds after the second airplane starts to turn, the third airplane starts its turn, keeping the nose ahead of the leader, pulling into position on the leader's INSIDE wing.

4 Formation should be formed by the time the squadron is opposite the airfield.

ALL AIRPLANES TAKE OFF IN THE ORDER OF JOINING FORMATION AT 30 SECOND INTERVALS. (TIMING FROM THE MOMENT PRECEDING AIRPLANE OPENS THROTTLE TO START TAKEOFF RUN)

Taxiing Out

Shortly before H hour, all ships start engines and stand by on interplane frequency. The formation leader checks with all planes in his formation. After this he calls the tower and clears his formation for taxi and takeoff instructions. As he taxies out No. 2 man follows, then No. 3, etc., each airplane taking the same place respectively on the ground that it is assigned in the air. As soon as the leader parks at an angle near the end of the takeoff strip, the other aircraft do likewise. At this point all aircraft run up engines and get ready for takeoff. The leader makes certain that everyone is ready to go before he pulls out on takeoff strip.

Takeoff

Formation takeoffs should be cleared from an airdrome in a rapid and efficient manner. Individual takeoffs will be made. Therefore, the following method is suggested.

The leader goes into takeoff position and takes off at H hour. No. 2 man starts pulling into position as soon as the leader starts rolling. When the leader's wheel leaves the runway, No. 2 starts taking off. (The time lapse is about 30 seconds.) The leader flies straight ahead at 150 mph, 300-500 feet per minute ascent, for one minute plus 30 seconds for each airplane in the formation. He levels off at 1000 feet above the terrain to prevent high rates of climb for succeeding aircraft. (Cruise at 150 mph.)

As soon as the leader has flown out his exact time, he makes a 180° half-needle-width turn to the left. The second airplane in formation assumes the outside or No. 2 position, while the third airplane assumes the inside or No. 3 position. The leader of the second element assumes position on the outside of the formation and his elements assemble on him in the same manner.

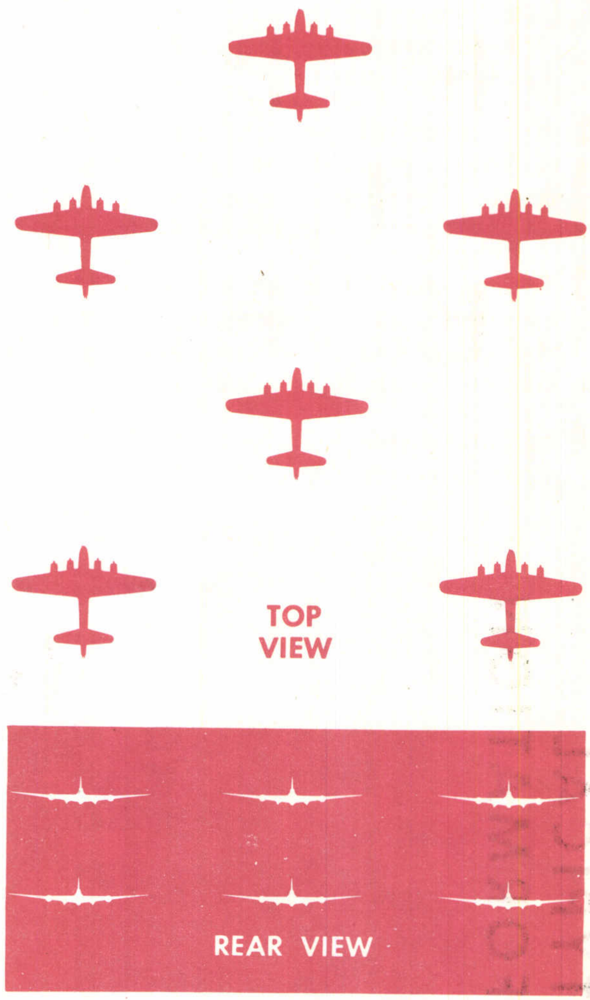
3-Airplane Vee

The 3-airplane Vee is the standard formation and the basic one from which other formations are developed. Variations of the Vee offer a concentration of firepower for defense under close control with sufficient maneuverability for all normal missions, and afford a bombing pattern which is most effective.

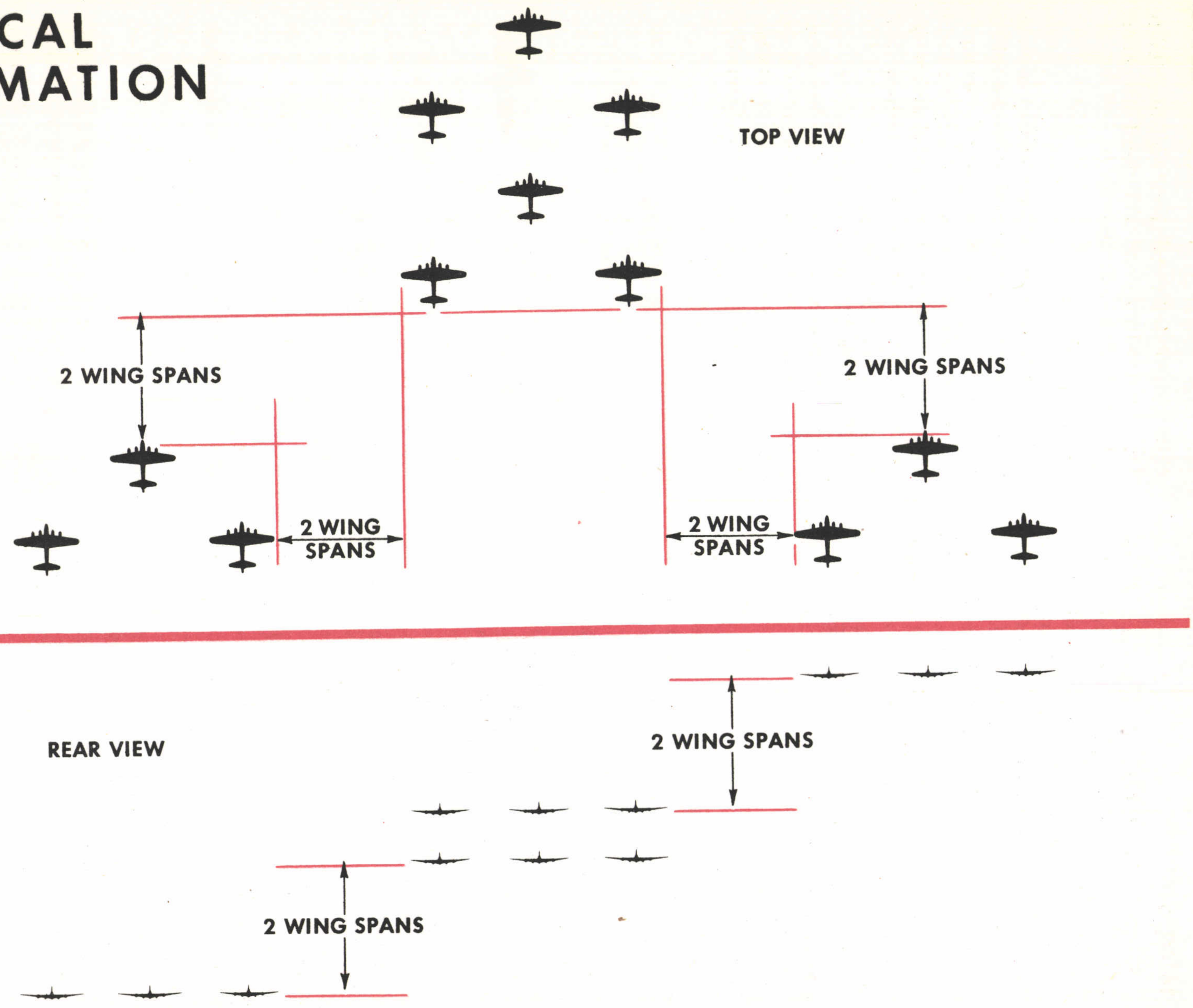
Flight of 6

A formation of 6 aircraft is usually known as a squadron which is composed of two 3-airplane Vees. One-half wing span vertical clearance will be maintained between elements in a flight and one-half wing span horizontal clearance between the leader of the second element and wingmen of the first element.

With but small variations, this basic formation can be changed to the combat formations used overseas. It is the job of training to teach a basic formation which can be readily understood and flown by students and easily adapted to tactical use.



TYPICAL FORMATION



12 Plane Formation

The 12-airplane formation is a maneuverable and compact formation which provides good defensive firepower. It is composed of: (1) the lead squadron of six airplanes (two elements of three airplanes each, stacked down in Vees); (2) a high element of three airplanes in Vee to the right and above the lead squadron; and (3) a low element of three airplanes in Vee to the left and below the lead squadron. The distances maintained in this formation are shown in the diagram on the opposite page.

TRANSITION FORMATION

Spacing of Wing Positions

It is particularly important for the leader to avoid violent maneuvers or improper positions which will cause undue difficulty for the wingmen.

The spacing of the wing positions in Vee formation is:

1. Vertically: On the level of the lead airplane.
2. Laterally: Far enough to the side to insure one-half wing span clearance between the wingtips of the lead airplane and the wing airplane.
3. Longitudinally: Far enough to the rear to insure one-half wing span clearance between the tail of the lead airplane and the nose of the wing airplane.

Turns in Vee formation will maintain the relative position of all airplanes in the element. In other words, the wing airplanes will keep their wings parallel to the wings of the lead airplane and on the same plane.

Practice Trail Formations

A formation is in Trail when all airplanes are in the same line and slightly below the airplane ahead. The distance between airplanes will be such that the nose of each succeeding airplane is slightly to the rear of the tail of the airplane ahead. If this distance is too great the propeller wash of the airplane ahead will cause difficulty in maintaining position. This formation will be used only when there are from 3 to 6 aircraft involved for changing the lead, for changing wingmen, for peel-off for landing (optional) and for training in leading elements.

Changing Wing Position in Transition

When changing from Vee to Trail, the wingman into whom a turn is made while in Vee assumes the No. 2 position in Trail, while the outside man is in the No. 3 position in the Trail. When returning from Trail to Vee, the No. 3 man in Trail assumes the inside position of the Vee. Remember this, for it is the procedure for changing from Vee to Trail and from Trail to Vee. Also, it provides a method for changing wing positions in a Vee formation.

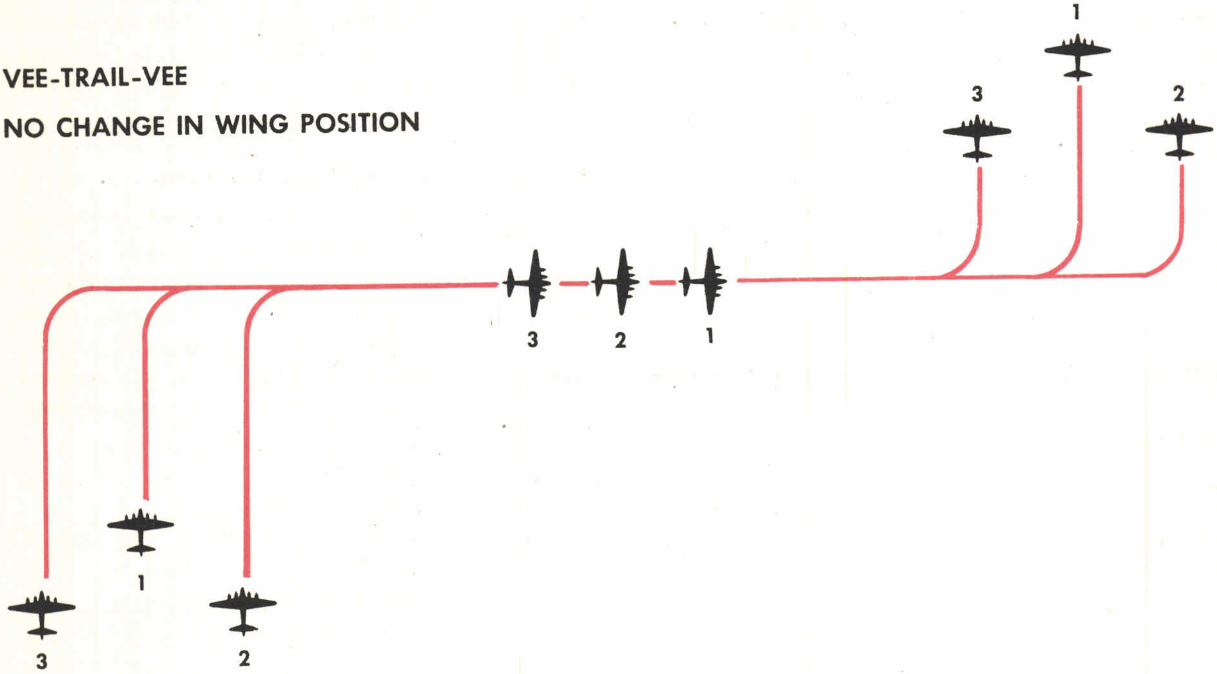
It is often desirable for a leader to change the wing position of his formation, i.e., to reverse the right and left positions. If this maneuver is not executed properly in accordance with a pre-arranged plan, there is danger of collision. A safe plan is for the leader to announce on the radio that the formation will go into Trail on his first turn. If the turn is executed to the right, it will result in the inside man, or No. 2 wingman, being No. 2 in the Trail, and the outsideman, or No. 3 wingman, being No. 3 in the Trail when the turn is completed. The leader will then announce that the formation will re-form in Vee when the Trail executes a turn to the right. This second turn to the right will re-form the Vee with wingmen reversed.

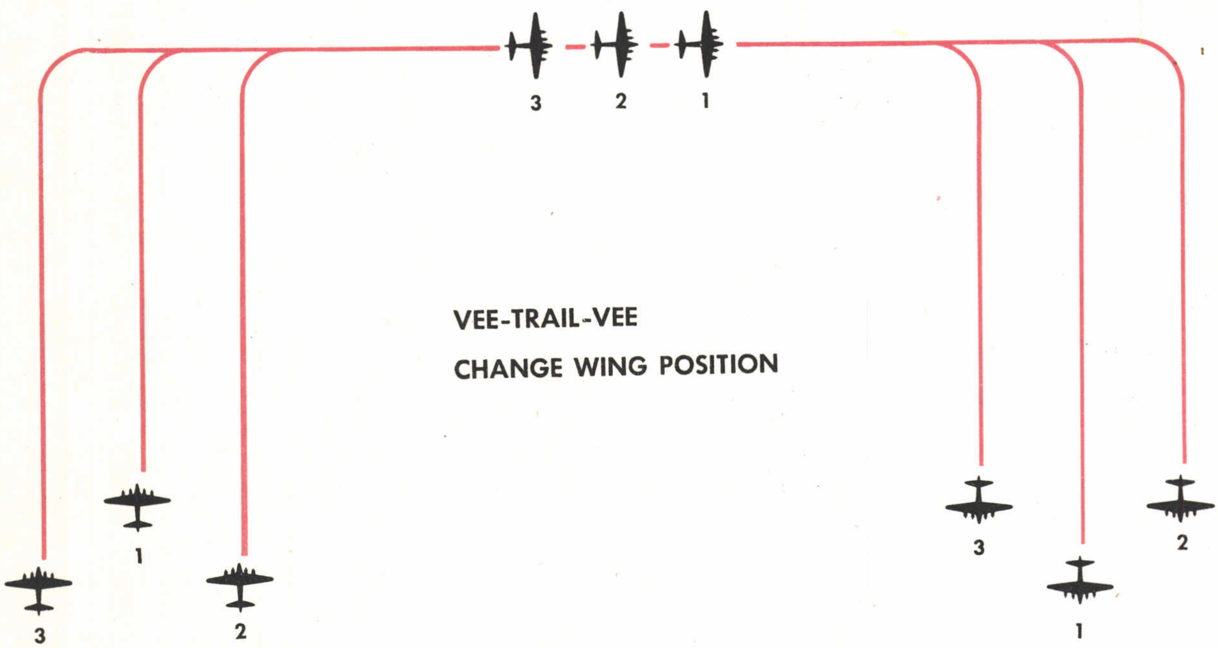
As stated above, this will result in the No. 2 man of the Trail assuming the outside position of the Vee, and the No. 3 man of the Trail assuming the inside position of the Vee. It is desirable for the leader to designate the ultimate position each wingman will assume prior to each turn in order to insure complete understanding.

CHANGING WING POSITION IN TRANSITION

VEE-TRAIL-VEE

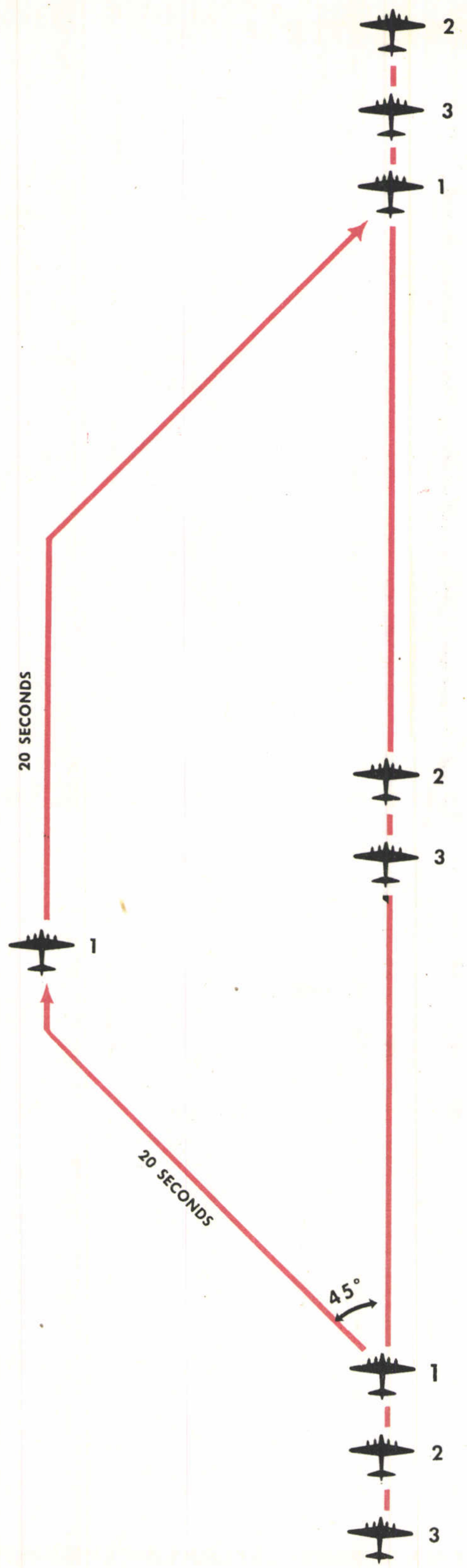
NO CHANGE IN WING POSITION





VEE-TRAIL-VEE

CHANGE WING POSITION



Changing Lead in Transition

Formation will go into Trail from the usual 90° turn to the right or left. The leader of the formation will make a 45° turn to the left and fly that heading for approximately 20 seconds or until such time as a turn back will place him in the rear of the formation. When the No. 1 airplane starts his 45° turn, the No. 2 plane in the Trail immediately becomes the leader of the formation and continues to fly straight ahead. At the end of 20 seconds, or thereabouts, the original leader turns back and takes up the No. 3 position in his element, or No. 6 position if in a flight of 6, and notifies the new leader that the maneuver is complete.

Landing from Vee in Transition

The formation will approach the airdrome at an altitude of 1500 feet above the terrain into the wind up the landing runway, at which time the wheels will be ordered down by the leader and checklist accomplished. The leader will signal No. 3, when over the edge of the landing runway, to peel off, No. 3 acknowledging by peeling off. No. 1 follows; No. 2 following No. 1; No. 6 following No. 2 and so on. Approach and landing accomplished as outlined.

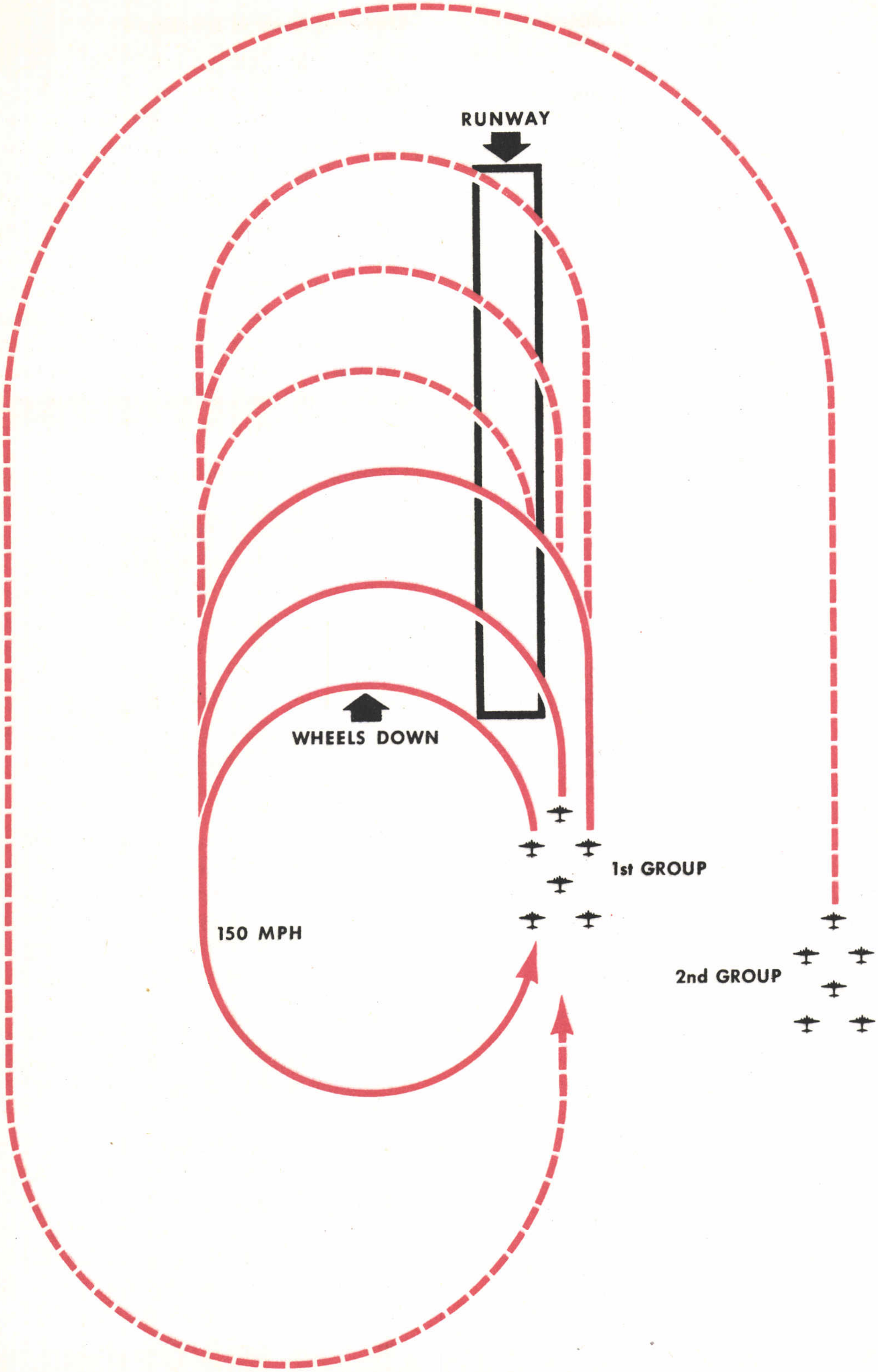
Group Landing

The group will approach the field with the low squadron at traffic pattern altitude (800 to 1000 feet). At the approach end of the runway, the left (low) squadron will peel off in the following order: No. 3, No. 1, No. 2. (If there are two elements, No. 6 peels off after No. 2, then No. 4, No. 5.)

After the last airplane in the left squadron has started to peel off, the lead squadron begins its peeloff, in this order: No. 3, No. 1, No. 2, No. 6, No. 4, No. 5.

When the last airplane in the lead squadron has started its peel-off, the right (high) squadron begins to peel off in the same order as the other squadrons: No. 3, No. 1, No. 2, etc.

If there is more than one group in the formation, the second group will make a 360° turn above traffic pattern altitude and approach the field after the first group has completed its peel-off.


RUNWAY
WHEELS DOWN
1st GROUP
150 MPH
2nd GROUP

Peel-off does not mean a chandelle or a dive. It should consist of a moderate, level turn away from the rest of the formation.

Conclusion

In conclusion, it should be stated that a good formation is a safe formation. An air collision is the result of carelessness or lack of clear understanding between members of the formation. If the simple rules, as outlined, are followed explicitly, there is no excuse for mistakes in the air. A mistake in formation flying may result in costly, irreparable loss of lives and equipment.

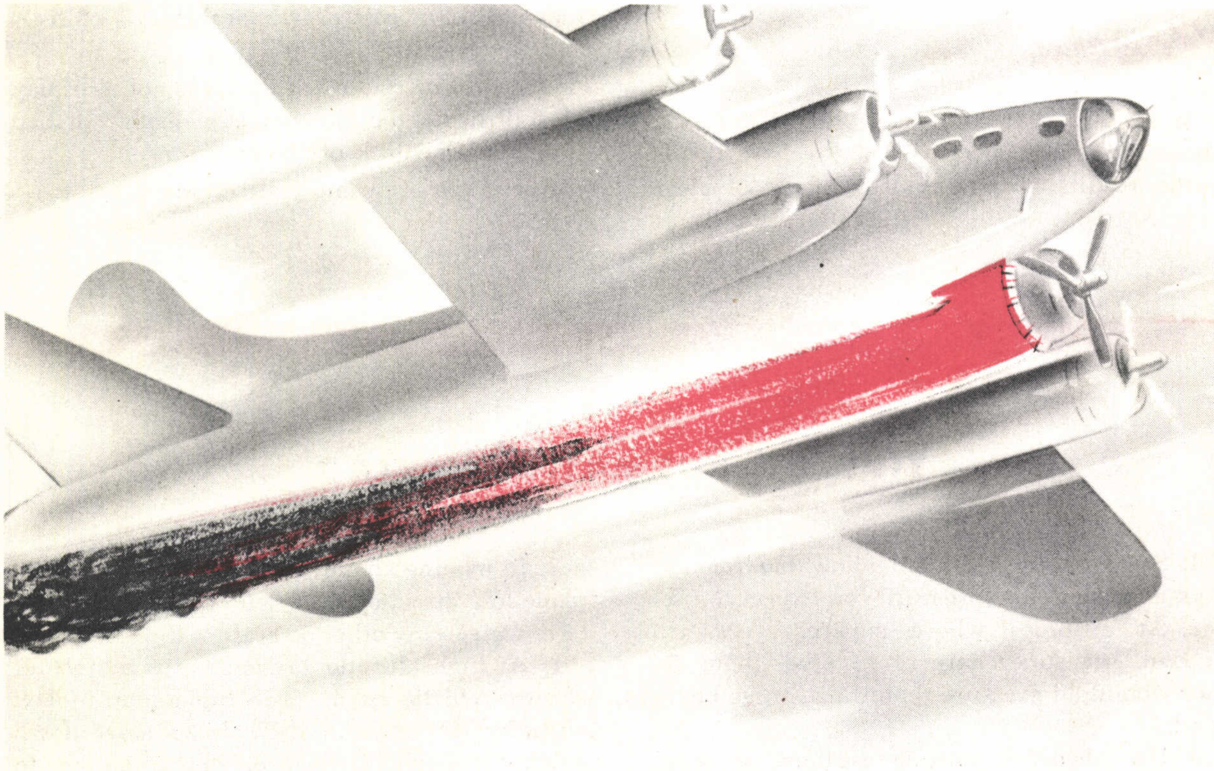
It should be reiterated that it is not a display of skill to fly too close; it is a display of bad judgment and lack of common sense.

Keep your crew and yourself alert!

TIPS ON FORMATION FLYING

1. Set rpm to minimum allowable for the maximum manifold pressure you expect to use.
2. At altitudes where superchargers are needed, set superchargers to give about 5" more manifold pressure than the average being used.
3. Use throttles to increase and decrease power to maintain position. But when far out of position, or when catching up with a formation, increase rpm to maintain proper manifold pressure and rpm relationships.
4. When under attack, use all available power required to stay in formation.
5. In cross-over turns, keep a sharp watch out for your side of the airplane and have the copilot do the same on his side. The pilot or copilot (whichever can see the airplane below) should automatically take over the controls. If neither pilot nor copilot can see airplane below, then bombardier should give instructions by interphone.
6. In changing leads in practice formations or in Trail positions, avoid closing to proper formation position too rapidly.
7. In moving about in position, move the airplane in a direction that will not interfere with or endanger any other aircraft in the formation.
8. At high altitudes, remember that rate of closure will be much more rapid than at low altitudes. It may be difficult to slow down quickly enough. Therefore, you will have to begin stopping the closure much sooner. On the other hand, acceleration is slower, so anticipation of change in position must be more acute.
9. Learn to anticipate changes in position so that only slight corrections need be made. Large corrections and constant fighting of the controls quickly wear out even a strong pilot.
10. Trim the ship properly. An improperly trimmed ship is difficult to hold in position.
11. Do not lock inboards and use outboards to maintain position. Use all 4 engines.
12. Whenever possible enter formation **from below** or on the level with the formation, **never from above.**
13. Rough air will make your position hard to hold. Be alert!

Emergency Procedures



FIRES IN FLIGHT

No emergency in an airplane is more serious than fire. Combat crews must always be conscious of the hazards involved in fire. They must be constantly on the alert for possible fire while in flight. They must be thoroughly familiar with methods of fire prevention and fire extinguishing.

Fires in flight can be prevented by more thorough preflight checks. Although most fires usually develop internally, many are caused by defects that could have been detected by visual inspection while on the ground. When making your visual inspection, look carefully for cracked or split exhaust stacks, excessive oil leakage, leaky primers, and gasoline fumes in the bomb bay or cockpit. All these are possible causes of fire in flight.

Be strict in forbidding smoking by crew members while transferring fuel in flight, and particularly when any gasoline fumes are detectable in the airplane.

Be careful in your checking procedure to see that the proper number of extinguishers are on board, and that the seals are not broken.

General Precautions

In case of fire during flight:

1. Warn all crew members to have parachutes attached in readiness for possible emergency use, and to stand by for orders.

2. If flying low, climb to safe altitude for possible bailout.

3. Determine whether airplane can be landed, or make plans for bailout.

Fire Inside the Airplane

1. Close all windows and ventilators.

2. If an electrical fire, cut electrical power to affected part.

3. If fuel line is leaking, cut fuel flow to affected line.

4. If fire breaks out in upper turret platform, close the oxygen shut-off valve on the pilot's seat frame.

5. Make immediate use of either carbon dioxide or carbon tetrachloride extinguisher—preferably carbon dioxide, if available.

6. If necessary to use carbon tetrachloride, stand as far as possible from the fire. The effective range of this extinguisher is 20-30 feet. Remember that carbon tetrachloride produces a poisonous gas—phosgene. Do not use in a confined area, and do not stand near the fire when using it. A very small concentration of phosgene may prove fatal. After extinguishing a fire with carbon tetachloride, open windows and ventilators.

Engine Fire in Flight

1. Alert the crew.
2. Open cowl flaps.
3. Close fuel shut-off valve.
4. Feather the propeller:
   a. Close throttle
   b. Press feathering button
   c. Mixture control in "IDLE CUT-OFF"
   d. Turn ignition off
5. Set fire extinguisher selector and release CO_2.
6. Lower landing gear if an inboard engine is on fire.
7. Complete after-feathering procedure.

The purpose of opening cowl flaps is to cool down the engine and to attempt to blow out the fire. The CO_2 is released in the accessory section, and the position of the cowl flaps does not affect its effectiveness.

Lower the landing gear if an inboard engine is on fire, to prevent the tire, brakes, etc., from burning. If you get the fire out, or need the gear up for a crash landing, retract it.

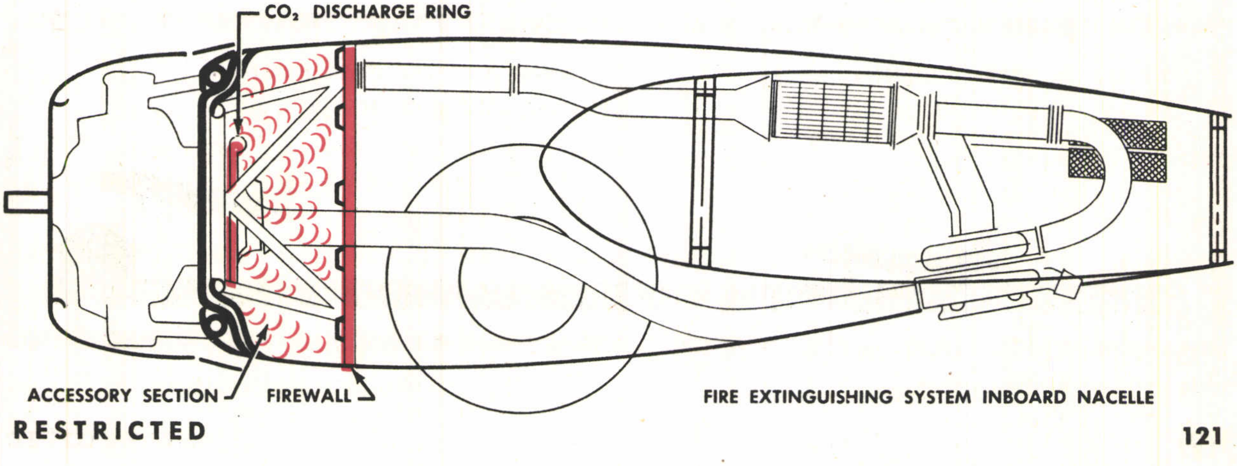
Engine Fire on the Ground

1. Open throttle wide (if engine is running).
2. Signal ground crew to use hand extinguishers.
3. If fire persists:
   a. Close fuel shut-off valve
   b. Mixture control in "IDLE CUT-OFF"
   c. Turn ignition off
   d. Set fire extinguisher selector and release CO_2
4. Call tower to rush crash equipment.
5. Cut all engines and get out of the airplane.
6. Do not use airplane until trouble is corrected.

Fires resulting from faulty engine-starting technique can often be sucked through the engine and extinguished by opening the throttle.

Fires caused by broken fuel primer lines, loose carburetor connections, etc., can be reached most effectively by the ground crew. Be sure the cowl flaps are full open to allow the fire guard to use an external extinguisher.

(The fuel shut-off valves are spring-loaded to stay in the "OPEN" position. They are closed by a solenoid actuated by electricity. If the electrical system is turned off, the fuel shut-off valves will spring open, even though the toggle switch on the pedestal is in "CLOSED."



FIRE EXTINGUISHING SYSTEM INBOARD NACELLE

MAXIMUM PERFORMANCE TAKEOFF

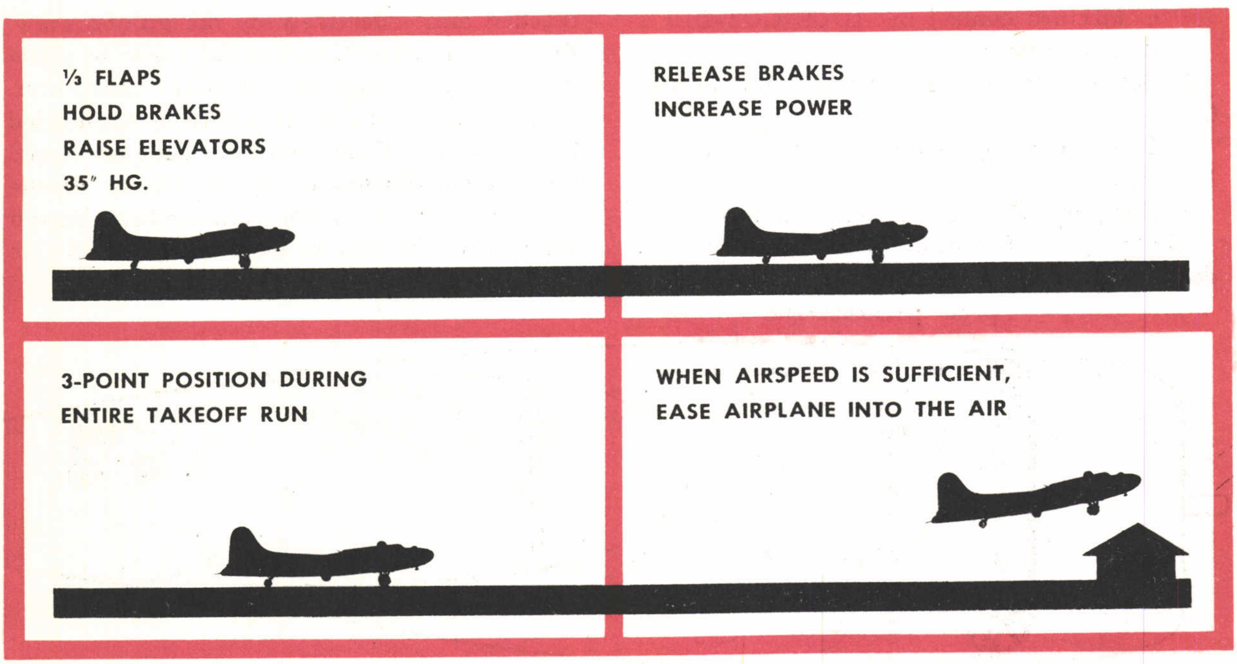
The purpose of this maneuver is to take off in a minimum distance—in other words, to make a short-field takeoff.

1. Line up with the runway and complete checks.
2. Put down ⅓ flaps.
3. Hold brakes, raise elevators to hold tail on the ground, and increase throttles to 35″ manifold pressure.
4. Release brakes and increase power by steadily and continuously opening throttles.
5. Hold airplane in 3-point position during entire takeoff run.
6. Keep cowl flaps fully open for takeoff even in coldest weather.
7. When airspeed is sufficient, ease the airplane into the air by pulling back slowly and steadily on the control column. If the airplane is properly trimmed, takeoff will require little back pressure.
8. Raise landing gear as soon as you are safely airborne.
9. When airborne, leave the flaps in the ⅓ down position until all obstacles have been cleared and you have attained about 140 mph IAS. When you raise flaps, be alert for the change in lift that results. Don't let the airplane fly into the ground.

Directional Control

During the earliest stage of the takeoff run, the airplane is inherently stable. **It will tend to move straight ahead in the direction it was pointing when brakes were released.** For this reason it is extremely important to line up properly before attempting the takeoff.

Do not use brakes to maintain directional control. Use rudder and throttle if necessary, as in a normal takeoff. Rudder remains relatively ineffective until considerable speed is attained. The best procedure is to establish the proper direction by lining up properly before takeoff.



3-Point Takeoff

Three general warnings concerning the 3-point takeoff must be mentioned to new pilots.

First, the airplane can be nosed over by holding brakes and applying high power **unless the tail is held down by the elevators.**

Second, never allow the 3-point takeoff to become a one-point takeoff. Be sure you know the feel of the airplane in a 3-point attitude. Otherwise, you may hold the tail down too far and too long, thereby causing the airplane to stall off the ground **tail last.**

Third, after you are airborne, there will be a noticeable tendency to climb steeply and the back pressure on the control column, which was needed on takeoff, should be relaxed to keep sufficient speed.

Use of Flaps

Putting down 1/3 flaps before releasing brakes (rather than waiting until 70 mph airspeed has been attained) is recommended for 2 reasons.

1. Takeoff is the most critical stage of flight operations. Waiting until you are 2/3 of the way down the runway to lower 1/3 flaps only complicates the procedure, and diverts attention from the actual takeoff to a dangerous degree.
2. Experience shows that even on a concrete runway there is actual improvement in takeoff performance by carrying as much weight as possible by winglift (i.e., with the use of flaps) instead of on the wheels. The advantage is even more marked where the takeoff surface is rough or soft.

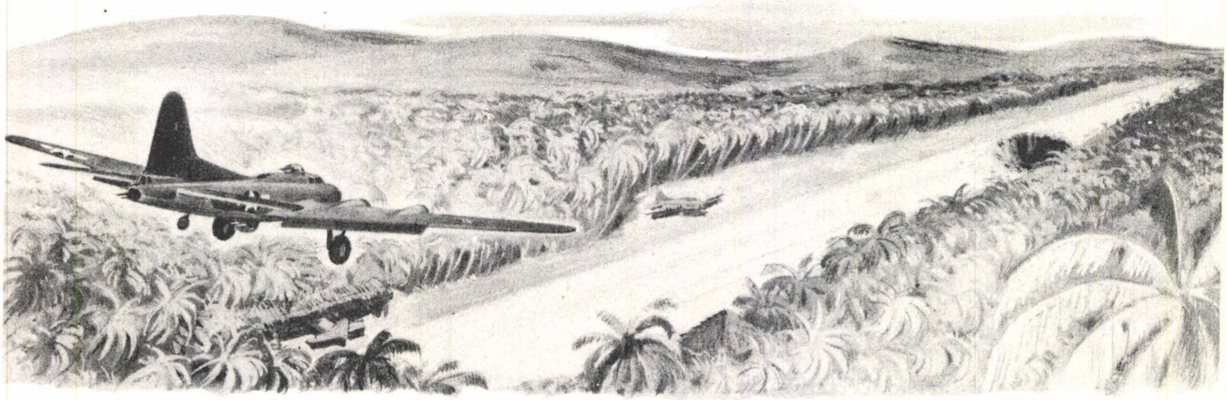
When flaps are raised, remember to raise the nose slightly to compensate for the change in lift.

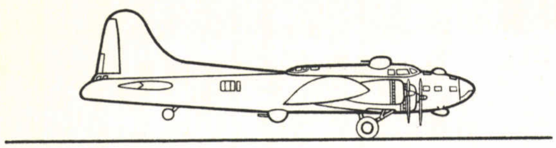
MAXIMUM PERFORMANCE LANDING

Here the purpose is to land the B-17 in the shortest possible distance.

1. Bring in the airplane for a normal 3-point landing.
2. On contact with runway, have copilot retract wing flaps and open cowl flaps.
3. Raise the tail with elevators to reduce angle of attack and thus hold more weight on the main wheels.
4. Apply brakes gradually but firmly until you have applied maximum pressure possible without skidding the tires. Remember that jamming on the brakes may cause the airplane to nose over.
5. Keep the tail off the ground as long as possible.

Be sure that brakes are not applied before the weight of the airplane has settled on the





KEEP TAIL OFF RUNWAY AS LONG AS POSSIBLE

runway. Resultant skidding will blow out the tires almost immediately.

If the airplane has to be groundlooped at the end of the runway, unlock the tailwheel **while there is no side load on it.** Any side load on the tailwheel at this time will bind the locking pin.

Clearing Obstructions

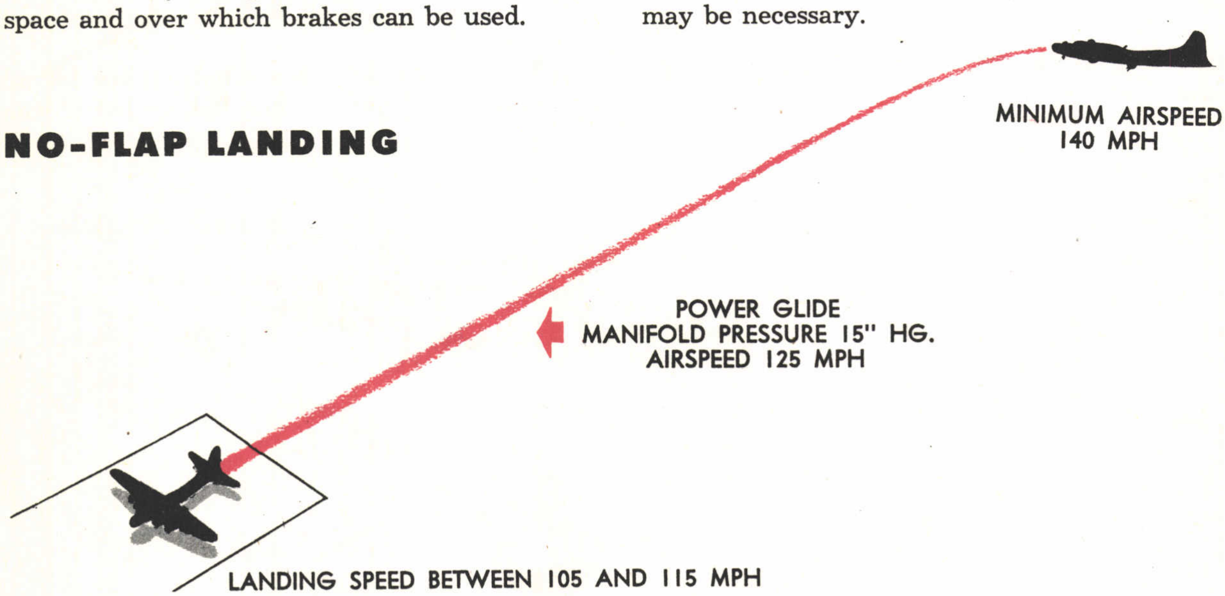
When an obstacle must be cleared in order to make a maximum performance landing on a short field:

1. Clear the obstacle at minimum safe airspeed.
2. Immediately after clearing the obstacle, steepen the glide so that it can be broken as soon as possible and contact made with the ground.
3. Immediately after contact, bring the airplane to the tail-high attitude and apply maximum braking power as described above. The slightly increased landing speed will be more than offset by the gain of additional runway space and over which brakes can be used.

NO-FLAP LANDING

If the flaps cannot be lowered for landing, you can make a no-flap landing safely.

1. Fly the traffic pattern just as you would for a normal approach with full flaps, **but maintain minimum airspeed of 140 mph until you are on the final approach.**
2. Set a power glide with manifold pressure of approximately 15″ Hg., and an airspeed of 125 mph.
3. The airplane will land at between 105 and 115 mph, depending on the gross weight. Therefore, be careful not to allow airspeed to drop below 120 mph until after breaking the glide.
4. Start the power glide at a point approximately ½ mile farther from the field than you would normally for a full-flap landing.
5. **Do not try a stall landing.** With no flaps, the airplane stalls at an extremely high angle of attack, and a stall landing is definitely tail first with a heavy shock on the main wheels when they drop in from three or four feet. When you reach a 3-point attitude, hold it until the landing is made.
6. This landing is extremely hard on brakes. Difficulty may be encountered in stopping the airplane before you run out of runway. Start using brakes immediately after the airplane has settled on runway. Several applications may be necessary.



EMERGENCY OPERATION

OF LANDING GEAR, WING FLAPS, AND BOMB CONTROL SYSTEM

If you cannot operate landing gear, wing flaps, or bomb bay doors by usual electrical means, try to work them by the use of the hand cranks. The cranks, with extensions, are stowed on the aft bulkhead of the radio compartment.

Landing Gear

You can operate each main landing gear separately through the hand crank connections in the bomb bay. One connection is to the left of the door in the forward bulkhead, the other is on the right.

To raise or lower the wheel, insert the hand crank into the connection and turn in the direction indicated on the bulkhead. The direction of rotation will vary with the type of retracting motor.

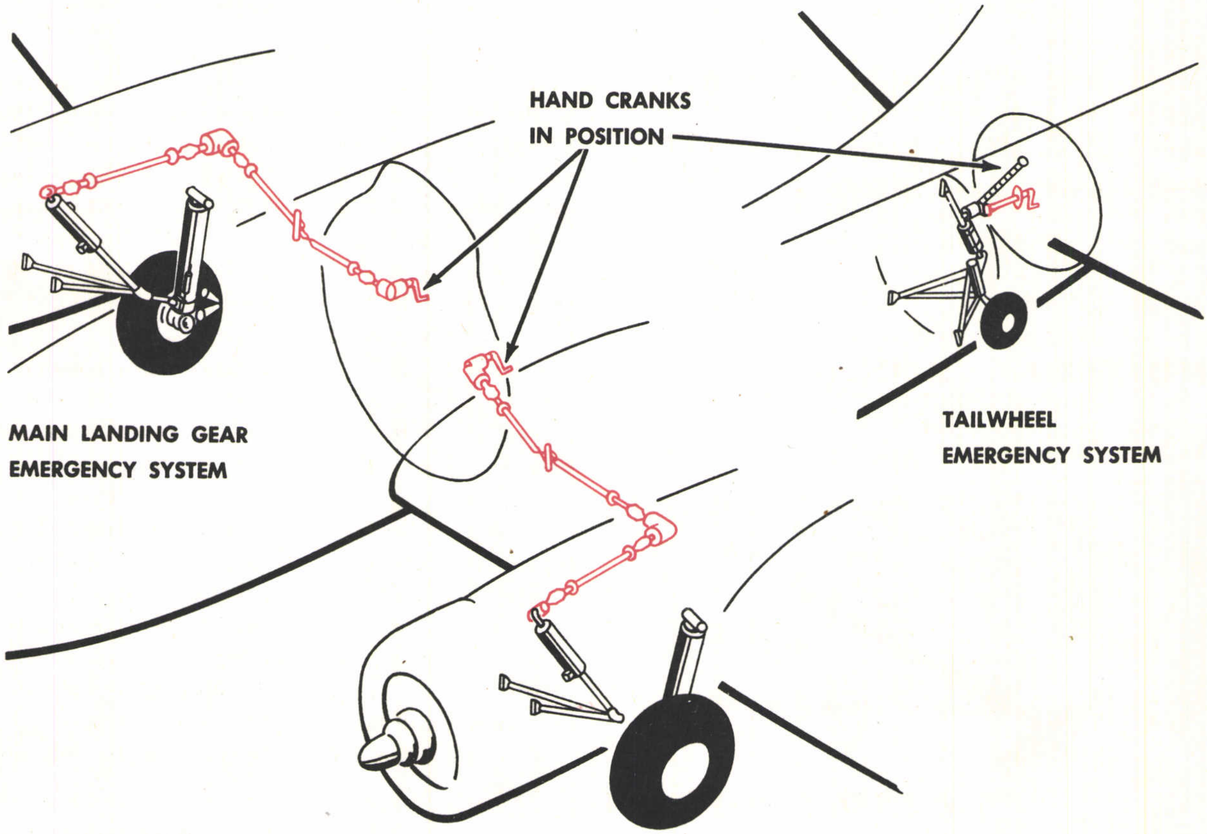
If bomb bay tanks are installed you must use a one-handed crank. The two-handed (long handle) crank will not fit between the bulkhead and the bomb bay tanks.

Be sure the landing gear electric switch is in the "OFF" position before attempting to raise or lower wheel by hand cranking.

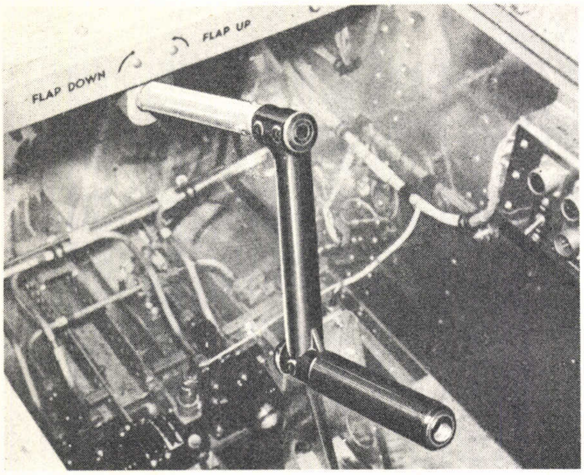
Tailwheel

Use the same crank for manual operation of the tailwheel. Insert the crank into the connection in the rear of the tailwheel truss and rotate as desired.

Be sure the landing gear electric switch is in the "OFF" position before attempting hand cranking.



Wing Flaps



Crank Installed

Lift the camera pit door (in the floor of the radio compartment) and insert the crank and extension into the torque connection at the forward end of the pit. Rotate the crank clockwise to lower flaps, counterclockwise to retract them.

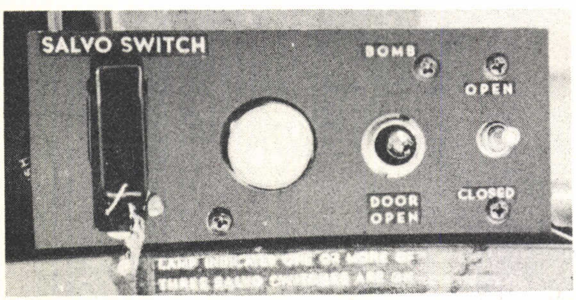
Be sure the electric switch is "OFF" before hand cranking.

Extending the flaps manually takes time. Anticipate this, so that you can get flaps down at the correct time for landing.

Bomb Control System (All-Electric)

In airplanes equipped with the all-electric bomb control system, the bomb bay doors can be opened electrically in three ways:

1. Use the door switch on the bombardier's control panel.
2. Use the door switch on the panel above the pilot's instrument board.

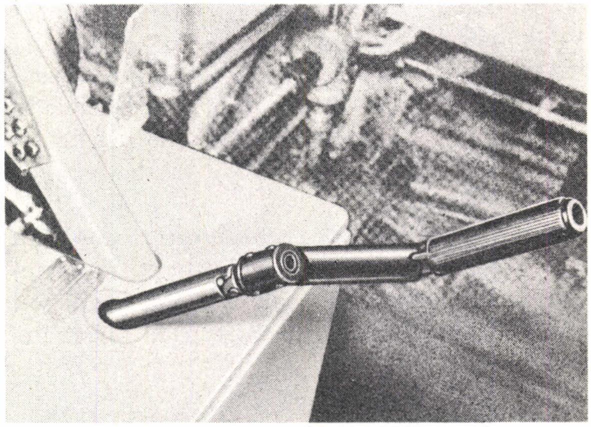


Pilot's Salvo Switch

3. Use either of the three salvo switches:
   a. On bombardier's control panel
   b. On panel above pilot's instrument board
   c. On forward end of bomb bay

Note: When any salvo switch is used all bombs or fuel tanks in the bomb bay are released and an indicator light at each location is lighted when **any** salvo switch is operated.

Bomb Control System (Electric—Manual)



Crank Installed

The bomb bay doors can be opened manually by using the hand crank. Insert the crank and extension into the connection in the step at the forward end of the catwalk in the bomb bay. Rotate counterclockwise to open the doors, clockwise to close them. Use of the hand crank simply opens and closes the bomb bay doors; it does not salvo the bombs.

Two emergency bomb release handles open the doors and salvo the bombs. One is at the pilot's left, and there is another at the forward end of the catwalk in the bomb bay.

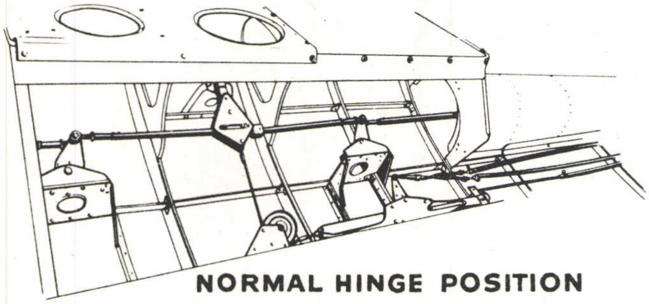
Pull the handle through its full travel. The first part of the stroke unlocks the bomb bay doors independently of the retracting screw and permits them to be held open by wind pressure. The second half of the stroke releases all external and internal bombs, in salvo and unarmed. In late airplanes the emergency release only opens the bomb bay doors.

To retract the doors after emergency release of bombs:

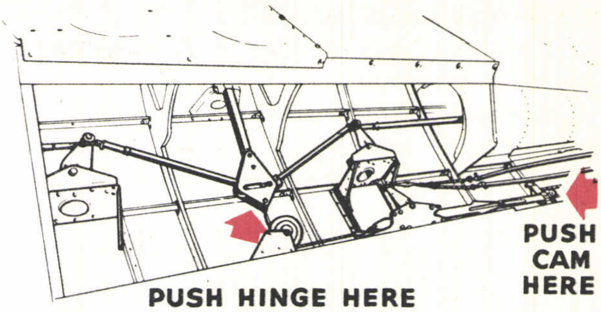
1. If the spring in the emergency release mechanism (under the hinged door beneath the pilot's compartment floor) has not retrieved the linkage entirely, re-set by pushing the hinge of the link.

2. Operate the retracting screws electrically (or manually, if necessary) to the fully extended position. This will engage the latches between the screws and the door fittings.

3. Now close the doors in the normal manner.



Link O.K.



Note

If your attempts to lower gear, flaps, or bomb bay doors by hand cranking don't work, turn off electric switches (batteries and generators) and try the hand crank again. As soon as the desired operation is completed, or it is clear that it won't work, turn battery and generator switches back on.

Remember the effect that shutting off electric power has on electrically operated turbos, radios, and inverters and be prepared for it.

DROPPING THE BALL TURRET IN FLIGHT

When preparing to bring the B-17 in for an emergency wheels-up landing, it is desirable to drop the ball turret in order to minimize damage to the fuselage when it hits the ground.

It is both safer and easier to release only the turret ball itself, leaving the supporting yoke intact. Only 2 tools—a crescent wrench and a hammer—are needed to do the job. Two men can accomplish it in approximately 20 minutes.

1. Point the guns aft or down and remove the azimuth case, which is held by 4 bolts.

2. Remove the safety retaining hooks. These 4 hooks can be broken off with a hammer, or they can be removed with a socket wrench if one is readily available.

3. Remove 10 of the 12 yoke connection nuts, leaving one nut on each of two diagonally opposed yoke legs. Then unscrew remaining nuts a half turn at a time until the turret drops out.

The turret may hang momentarily on the fire cut-off cam, but a firm kick on the aft side of the ball will dislodge it.

It is desirable, but not absolutely necessary, to disconnect the electrical plug and oxygen line before removing the yoke nuts.

If time permits, the computing sight can be salvaged by first entering the turret and disconnecting the 3 flexible drive cables at the left, right, and far side of the sight. Free the sight by removing the sight retaining rod and disconnecting the electrical plug. Removal of the sight may add approximately 20 minutes to the time, making the total time necessary for the operation about 40 minutes.

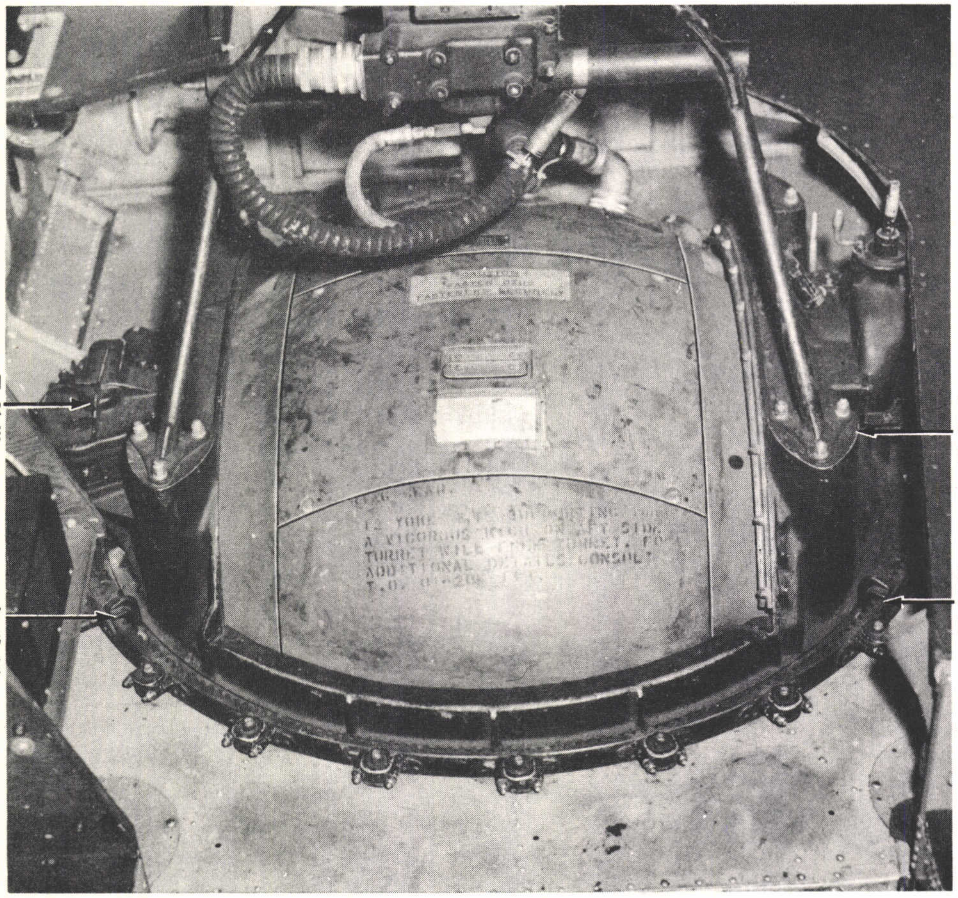
Remember these rules for making emergency landings:

1. When landing the B-17 **with main wheels up**, drop the ball turret.

2. When belly-landing a B-17, always lower the tailwheel if possible.

3. If chin turret is installed, make sure that guns are pointing up.

4. Landings with the tailwheel and one main wheel down do not require dropping the ball turret, but make sure the guns are not pointing down.



DROPPING THE LOOP ANTENNA

In belly landings, considerable damage is often done to the underside of the fuselage of the airplane by the loop antenna breaking loose and rolling back as the airplane slides along. For this reason the loop antenna on late airplanes is now designed so that it can be jettisoned in flight.

To jettison, break the lockwire, remove the 8 wing nuts, and remove the electrical connections as instructed on the adjacent decal.

It is not necessary to jettison the antenna when landing is to be made with one main wheel fully down.

LANDING DISABLED AIRCRAFT

General

Whenever possible, land aircraft with disabled landing gear on a runway, not on the grass. Experience has shown that landings on a runway result in less damage to the airplane and less chance of injury to the crew.

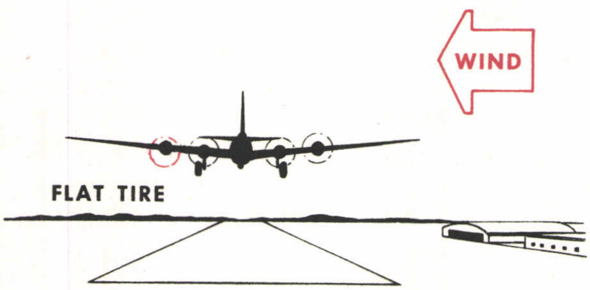
When you land on grass with one or more wheels not fully down, mounds of dirt build up in front of the skidding airplane, causing greater deceleration and often resulting in a groundloop. On a hard surface runway the airplane usually slides straight forward and decelerates more gradually.

Whenever you are bringing in a disabled airplane for landing, inform the tower and explain your trouble. Do this in time for the field to be cleared and crash equipment brought up.

Most landings of B-17 airplanes with disabled landing gear have been made with no injury to the crew and many with only minor damage to the airplane. If you follow proper procedure for such landings you will have little difficulty.

Landing on One Flat Tire

1. Bring the airplane in at a normal glide, using full flaps, for a normal landing.
2. Don't make an effort to land on the good tire. However, if one wheel is to come in contact with the ground first, make it the good one.
3. Hold elevators all the way back immediately after landing.
4. Use the brakes on the good tire only.



5. Use the outboard engine **on the side of the flat tire** to counteract any tendency to groundloop on that side.

If possible, land the airplane crosswind, with the wind coming from the side with the good tire. This crosswind tends to make the airplane turn into the wind; but the effects of the wind and the flat tire tend to equalize, making it less difficult to keep the airplane straight.

Landing with Cracked or Wobbling Wheel

1. Land directly into the wind, making a normal 3-point landing.
2. Use brakes on the good wheel only.

Experience shows that in most cases the damaged wheel will stand up for a final landing, with no damage to the airplane.

Landing with only One Main Wheel Down

For landing on a runway with tailwheel and one main wheel down, the other main wheel retracted or only partially extended:

1. Tie down all loose equipment.
2. Use up or dispose of all unneeded fuel.
3. Complete the before-landing checklist.
4. Leave good gear and tailwheel down.
5. Bring the airplane in for a normal power approach, directly into the wind if possible.
6. Use full flaps, as for a normal approach.
7. Make what would be a normal 3-point landing, except for the fact that only one main wheel is down.

Keep the airplane going straight by using good wheel brake if necessary.

9. When airplane stops, cut engines and switches and get crew out.

Landing with Broken Drag Link

Follow the procedure used for landing with one main wheel up, except that immediately after contact with the ground, pull back on the control column sharply. This lifts the nose slightly.

As soon as it touches the ground, the wheel on the damaged gear will begin to spin, the main strut of the gear should hit the stop and bounce forward. If you have timed your back pressure on the control column properly, the wheel will come forward of the vertical position and when the weight of the airplane settles, the wheel will rock forward and into its nacelle.

As the landing is being made, either pilot or copilot watches the position of the damaged wheel. If the maneuver fails to force the wheel forward and into its nacelle, it is possible to advance the throttles and go around, but landing with the wheel swung back under the wing is not too serious.

Landing with Tailwheel Retracted or Damaged

If you cannot get the tailwheel fully down, extend it as far as possible. Then follow the procedure for landing with one main gear retracted, with these exceptions:

1. Make a wheel landing.
2. Hold the tail up as long as possible by careful use of elevators and brakes.

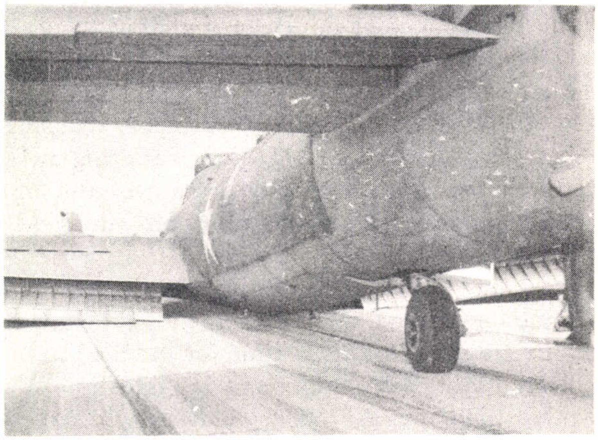
Be sure not to apply brakes before the airplane has settled on the runway. If you do, the tires will blow out and you may nose over.

Belly Landings

For belly landings—both main wheels up, or only partially extended—follow the procedure for landing with one main wheel retracted, with these additions:

1. If the ball turret and loop antenna can be dropped, drop them.
2. Put the tailwheel down if possible.

Make as smooth landing as possible. **Do not feather the propeller of a good engine.** You need all the power and control you can get for this maneuver. Further, a feathered propeller hitting the ground can tear the engine out of the airplane.



WHEN LANDING DISABLED AIRCRAFT ON AN AIRFIELD, PUT DOWN AS MUCH GEAR AS POSSIBLE.

WHEN LANDING AWAY FROM AN AIRFIELD, LAND WHEELS-UP.

RUNAWAY PROPELLERS

The most important fact to keep in mind about a runaway propeller is **not to feather it** until you have tried the 2 procedures which should give you control of it. Drill your copilot in these procedures, so that he will understand his part in controlling a runaway propeller.

What Causes a Propeller to Run Away

When a propeller runs away, it simply means that the propeller governor has failed to hold the propeller at its constant rpm setting. Thus, before takeoff, when engines are idling, the propeller is in "HIGH RPM." Sudden application of power may cause a propeller to exceed the governor limit speed before the governor has a chance to increase pitch. The governor cannot regain control until you throttle back and give it a chance. This is usually the case with a runaway propeller.

However, if you have complete governor failure, you may not be able to regain control with throttles or with propeller controls, and will have to use the feathering button intermittently as described in the following procedures.

Preventive Action

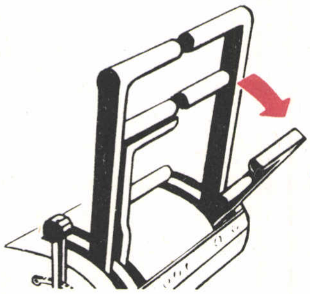
The best way to cope with a runaway propeller is not to get one! Carefully observe tachometer reaction during run-up. Don't jam on power during takeoff. Apply it smoothly.

How to Regain Control

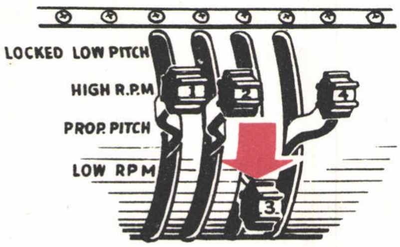
Always try this first, during takeoff and in flight. It may give you immediate control over the runaway propeller so that you can obtain a normal rpm setting.

First procedure:

1. Reduce the throttle. This is the first step necessary to slow down the propeller.



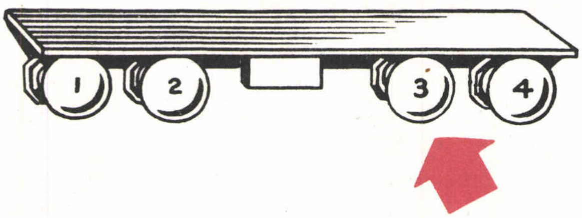
2. Push down propeller control to cut rpm.



3. If this works, re-set your throttle, keeping close watch on rpm. If it fails, resort to the second procedure.

Second procedure: (This procedure is recommended for takeoffs and for heavily loaded airplanes because it gets more power.)

1. Reduce the throttle.



2. Copilot, at pilot's direction, pushes in the feathering button, holds it in, and watches rpm. **(Be sure to get the right feathering button,** or you'll be short 2 engines. Take your time!)

3. As propeller rpm decreases, increase the throttle to obtain climbing manifold pressure and 2500 rpm.

4. When rpm reaches 2500, forcibly pull the feathering button out. This will keep the rpm from decreasing further. If the governor does not take control of rpm, it will immediately start back up.

5. When propeller reaches 2760 rpm, push feathering button in, repeating procedure to keep rpm between 2500 and 2760 and maintain desired manifold pressure. Continue this until you attain an altitude where you can go around safely and land, or where you can feather the propeller.

Caution

Don't be in a hurry to feather. If either of these procedures is keeping the propeller below 2760 rpm, you are getting some power from the engine, possibly as much as 15% with the throttle retarded, and up to 65-70% by using the second procedure.

Note: If neither method of controlling the propeller works and you can't feather, cut engine with mixture control and ignition switch. The engine will stop, but the propeller will continue to windmill. Slow the airplane to lowest safe speed to reduce windmilling.

OVERSPEEDING TURBOS

1. Throttle affected engine to desired manifold pressure.

2. Close turbo control. (If electronic system is installed, change amplifier on turbo.)

3. Try to maintain desired power with throttle.

4. Try to re-set the turbo for operation without overspeeding. Usually, there is a position where the turbo will stay within operating limits.

During this operation, maintain directional control with rudder. Never throttle back the opposite engine unless full rudder fails to hold the airplane on a straight course.

On takeoff, never feather an engine if the turbo or propeller can be brought under control. Bear in mind that you will need all the power you can get.

BRAKE OPERATION WITH HYDRAULIC PUMP FAILURE

If pressure in the main hydraulic system is lost, or the electric hydraulic pump fails, the hand hydraulic pump located on the floor to the right of the copilot may be used to rebuild accumulator pressure or supply pressure direct to brakes. **However, do not attempt to taxi if hydraulic pressure will not build up automatically. Stop the airplane and have it towed back to the line.**

It takes considerable time—about 400 strokes for 600 lbs. pressure—to build up the accumulator. To operate: check the hydraulic selector valve in the "NORMAL" position (it is usually wired in this position) and use the hand pump.

As 600 lbs. pressure will furnish only a few brake applications, this pressure must be used sparingly. Don't pump the brakes; apply them with steady, continuous pressure until the airplane is stopped.

If there is no time to build up the accumulator pressure, and brakes are needed, depress the brake pedals and have the copilot operate the hand pump. The pump will have no braking action unless the brakes are depressed.

There will be no resistance to the first few (3 to 10) strokes of the hand pump. The copilot must keep on pumping until the airplane stops. It may take 25 full strokes to stop an airplane that is barely rolling.

Bear in mind that the hand pump operation supplies direct action to the brakes when the pedals are depressed, and very little if any pressure is being stored in the accumulator. When you release the brake pedals the pressure will be dissipated through the brake metering valves to the return lines.

Caution

Do not depend on the hand pump to furnish pressure for taxiing. The action of the pump is much too slow. If the hydraulic pressure will not build up automatically, stop the airplane and have it towed back to the line.

EMERGENCY HYDRAULIC SYSTEM

The emergency hydraulic system consists of an additional accumulator charged by the electrically driven pump, and 2 manually operated metering valves located in the roof of the pilot's compartment.

The system operates the brakes only: the left hand lever controls the left wheel brake, the right hand lever controls the right wheel brake. Pulling the handles downward directs pressure from the emergency accumulator through the auxiliary brake lines. This provides braking control in the event that the main hydraulic system has failed.

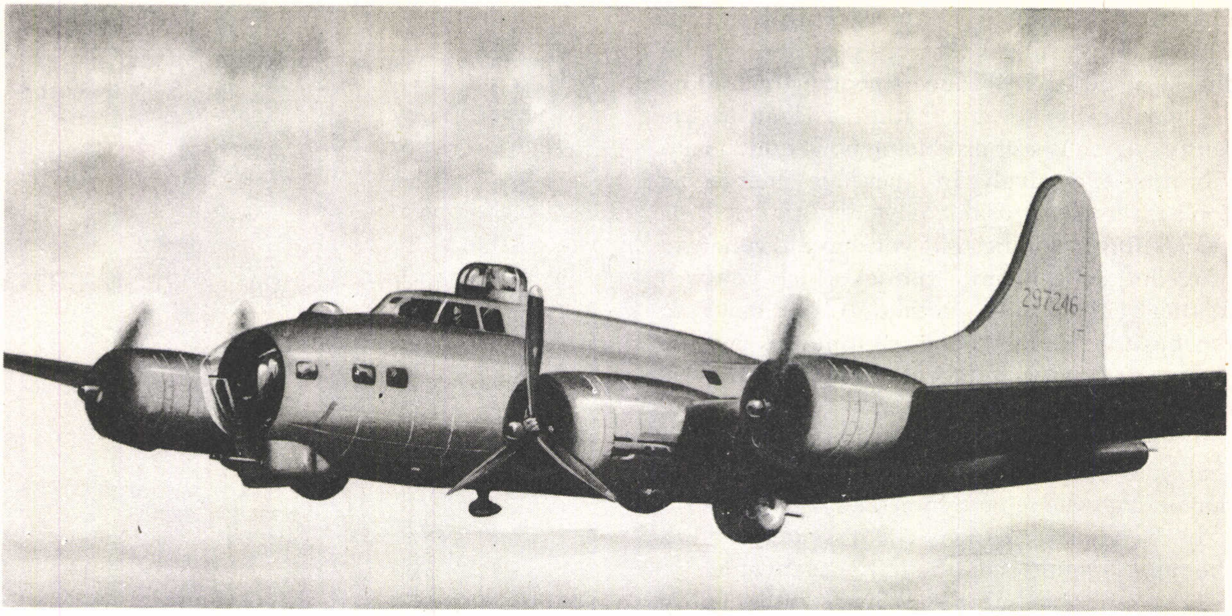
If it is necessary to rebuild the pressure in the emergency system, follow this procedure:

1. Manual shut-off valve to "OPEN."
2. If a selective check valve is installed, place it in "SERVICING" position (unless it is lock-wired in "NORMAL" position).

The emergency pressure will build up from the main hydraulic system. When the system pressure reaches 800 lbs., turn the manual shut-off valve to "CLOSED" and return selector valve to "NORMAL."

Do not pump the emergency hydraulic brakes. Pressure in the emergency system is limited (approximately 4 applications) and pumping will result in early loss of emergency brake control.

If pressure in the emergency system is lost, use the hand pump (on the floor to the copilot's right).



FEATHERING PROPELLERS

Feathering mechanism is incorporated in propellers for two reasons: (1) to reduce drag when the airplane must continue flight with only 3 or 2 engines operating; (2) to eliminate vibration of a damaged engine that might otherwise weaken the airplane's structure.

To Feather or Not to Feather?

Feathering is an important and valuable procedure—when needed. When you're satisfied that feathering is indicated, and you're sure you know what you're doing, don't be afraid to feather. But don't be too hasty in hitting that feathering button. Be sure you know when to feather. Be sure you clearly understand the advantages to be gained by feathering. **Be sure you feather the proper propeller.**

When to Feather

When confronted with engine trouble, and the question of whether or not to feather the propeller on the damaged engine, follow these rules.

1. Be calm, think clearly, move slowly. Your problem is to decide whether or not to feather; and, if feathering is indicated, to feather the proper propeller.
2. Be sure that the real trouble lies in the engine, not in your engine instruments. If oil pressure drops, for instance, check your oil temperature gage: oil temperature will rise if anything is radically wrong (unless you're out of oil).
3. If you have doubts about whether an engine is dead and windmilling or not, work the throttle back and forth. You should be able to feel the difference in power by the yaw if the engine is still operating.
4. Rpm is another indication of power. To check a suspected engine, put the propeller control in "HIGH RPM" and check the tachometer. The propeller of a dead engine will not normally windmill above the following limits: 2500 rpm at 160 mph, 2100 rpm at 150 mph, 2000 rpm at 130 mph.

Note: This check will not work at altitudes higher than 10,000 feet.

5. If there is a rise in manifold pressure when the turbo control is advanced, the engine is delivering some power.
6. If an engine is running rough, try a change

in power settings or mixture control setting. Check intercooler control position. These checks sometimes produce smoother operation.

7. Generally, do not feather as long as the faulty engine is still producing power and is not vibrating excessively. In a possible emergency, don't throw away usable power.

8. Before deciding that you have a runaway propeller, set a definite rpm at which you will feather (2760 rpm maximum). Unless rpm reaches that danger point, continue to operate the engine with reduced manifold pressure, especially on takeoff.

9. Once you have decided to feather, be sure that you feather the correct propeller and not one on a good engine by mistake.

10. Tendency to turn will indicate whether the faulty engine is on the left or right side.

11. Noticeable vibration often will identify the faulty engine.

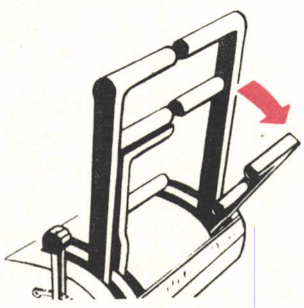
Most B-17's have been modified to incorporate a reserve supply of oil for feathering, by means of a standpipe in the oil tanks. Therefore, when oil pressure drops you can afford to wait, before feathering, to see if oil temperature rises, a double check on whether the oil pressure is really low.

If there is no reserve supply and oil pressure falls to 30 lb., feather the propeller at once.

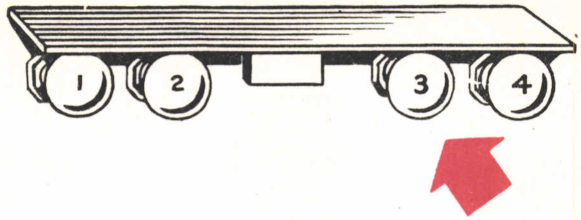
HOW TO FEATHER

When you have decided to feather and **are sure** that you are feathering the correct propeller, follow this procedure:

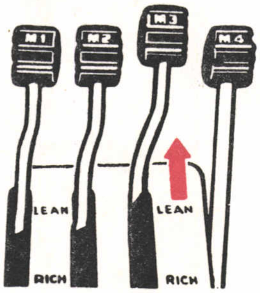
1. Close throttle fully.



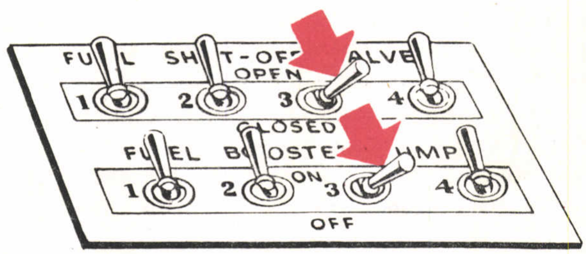
2. Push feathering button.



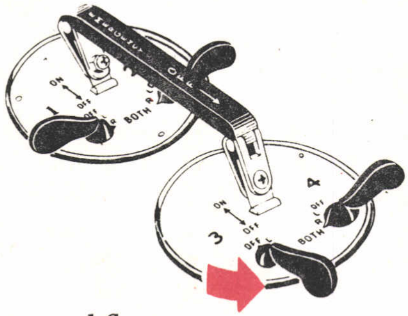
3. Move mixture control to "IDLE CUT-OFF."



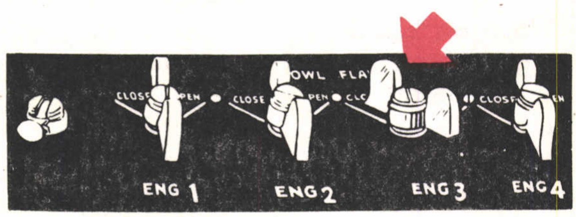
4. Switch fuel shut-off valve to "CLOSED."
5. Turn booster pump "OFF."



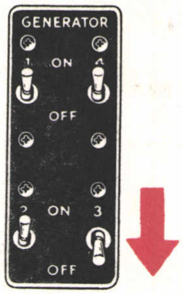
6. Turn ignition "OFF."



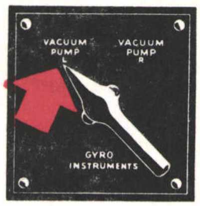
7. Close cowl flaps.



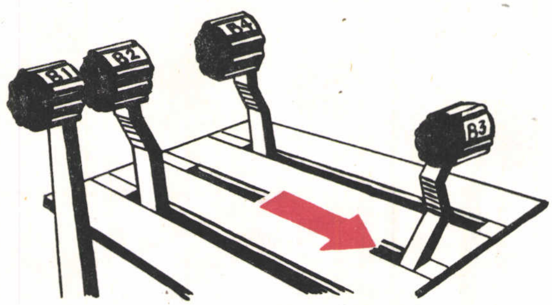
8. Turn generator "OFF" and remove regulator.



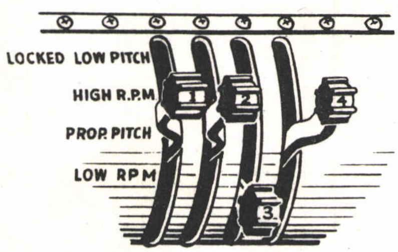
9. Place vacuum selector to a good engine.



10. Turn oil regulated turbo "OFF." (Leave electronic turbo control as needed.)



11. Place propeller control in "LOW RPM."



Perform the steps in the feathering procedure quickly but surely. Make certain you are moving the correct controls and that you are moving them in the proper direction.

After the immediate steps have been taken care of, have the copilot adjust mixture controls on the other engines, and increase rpm and manifold pressure as required, if you have not already done so. Retrim the airplane. If landing gear is down, retract it unless you can land immediately or there is a fire in the inboard nacelle.

Five to ten minutes after feathering, switch the fuel shut-off valve to "OPEN" if there is definitely no fire in the affected engine. This prevents the solenoid in the valve from overheating.

Fuel should be transferred from the dead engine tank if needed.

In practice, never leave a propeller feathered any longer than necessary. The oil and engine cool rapidly and it may be difficult to restart the engine.

Emergency Measures

1. Tune the radio compass to nearest stations, so that you can use the radio compass needle for making turns and if instruments fail through loss of vacuum, you can maintain direction by homing from one station to another.

2. If vacuum is out and you have to fly on instruments, turn the automatic pilot "ON." Refer to tell-tale lights to maintain level flight attitude. **Don't turn on rudder, elevator or aileron switches.** This is used only as an additional aid. Otherwise use airspeed, ball, and compass.

Normally the feathering switch is released by hydraulic pressure built up in the system after the propeller has reached the full feathered position. Sometimes viscous oil in the propeller system builds up this trip-out pressure prematurely, preventing full feathering. If this happens, hold the feathering switch down until the propeller is fully feathered.

Accidental Unfeathering

In some cases hydromatic propellers have begun to unfeather almost immediately after reaching the full feathered position. The reason is that the switch failed to cut out automatically when the feathered position was reached.

Should this condition occur, pull out the feathering switch button as soon as the propellers begin to unfeather. Leave it out for 2

or 3 seconds, then close the switch again. When the full feathered position has been reached (indicated by the cessation of windmilling) pull the feathering switch button out again. This will prevent further unfeathering.

Failure of Feathering System

Total loss of engine oil in combat, or line failure in the engine oil system, will make feathering impossible (unless auxiliary supply is available). If normal feathering is impossible, try to make the propeller windmill at the lowest possible rpm. Since windmilling is proportional to airspeed, it can be reduced to a minimum by reducing airspeed to 20-30 mph above stalling speed (i.e., to approximately 120-130 mph IAS).

After you have completed feathering procedure and the propeller still doesn't feather, leave the propeller control in "LOW RPM" and fuel, throttles, ignition, and other controls in the "OFF" position.

A windmilling propeller can do great damage to an engine. It creates drag, and spoils some of the lift of the wing by causing burbling. If you cannot control the propeller, land at the nearest suitable airfield.

Engine Seizure

Frequently loss of oil for lubrication will cause the engine to seize and stop suddenly. In some cases of engine seizure the reduction gear housing will break, allowing the propeller, propeller shaft, and reduction gearing to fall off. In other cases, only the reduction gears will be stripped. This relieves the propeller of engine drag and permits it to windmill.

Unfeathering

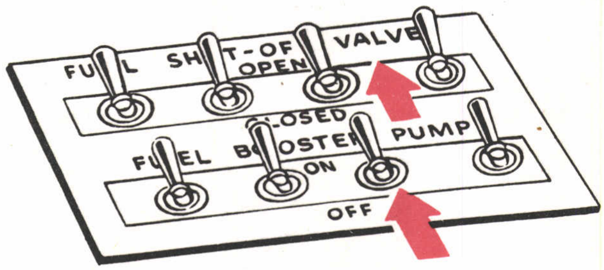
Never unfeather a propeller of a faulty engine unless it is needed for landing or continued flight. If the propeller was feathered because of engine damage, remember that unfeathering may result in still further damage.

Be especially careful in starting and warming up a cold engine. Oil drains into the bottom cylinder of a dead engine, and structural damage may result from re-starting the engine.

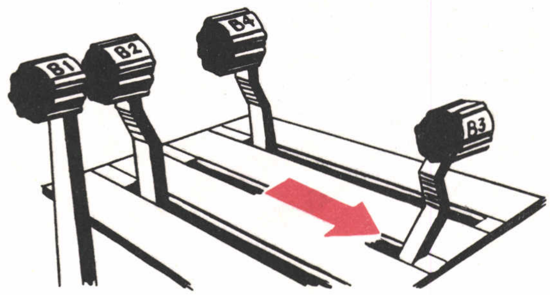
When practicing feathering, don't allow the propeller to remain in the feathered position for more than 5 minutes. Under cold weather conditions, unfeather the propeller at once.

HOW TO UNFEATHER

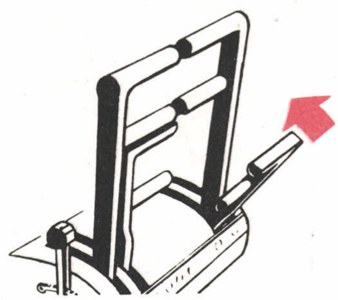
1. Switch fuel shut-off valve "OPEN."
2. Turn booster pump "ON."



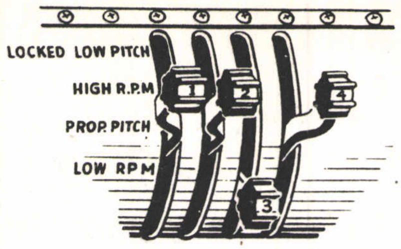
3. Turn turbo supercharger "OFF." (With turbos "ON" the waste gate is closed and if the engine backfires the waste gate and turbo may be damaged.)



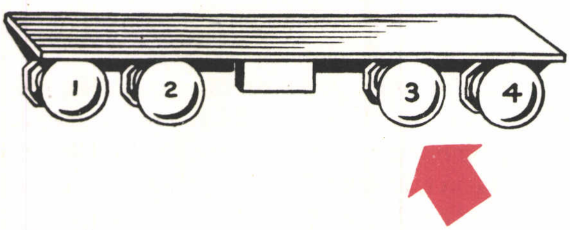
4. Set throttle to about 800 rpm (cracked).



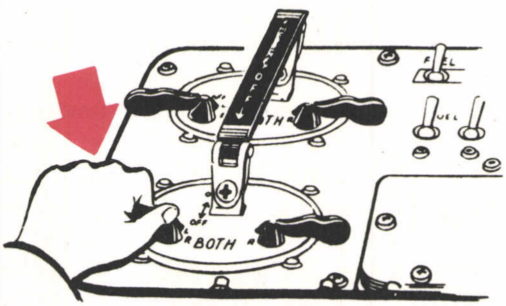
5. Set propeller control to "LOW RPM."



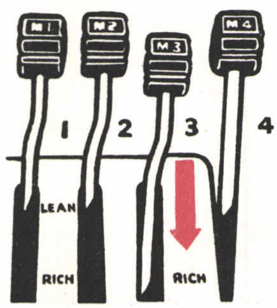
6. Depress feathering button until tachometer reads 800 rpm. If button doesn't pop out automatically when released, pull it out.



7. After engine turns over once, turn ignition switch "ON."



8. Place mixture control in "AUTO RICH" position.



9. Allow the engine to warm up at not more than 1200 rpm until cylinder-head temperature reaches 100°C. When engine is warmed up, adjust rpm and manifold pressure slowly to desired settings.

10. Turn generator "ON" when engine rpm reaches 1500.

Remember that even when an engine has been stopped for only a few minutes it has cooled off and must be allowed to warm up before you can pull much power from it.

ONE-ENGINE FAILURE ON TAKEOFF

If a power failure occurs during the takeoff run, the pilot must decide immediately whether to continue the takeoff or to stop. If sufficient runway remains, throttle engines and stop. If the takeoff must be made, use all available runway and take off when speed reaches 110-120 mph. If the failure occurs just after takeoff, when power is at maximum allowable, reduce drag as much as possible by raising the wheels and trailing the cowl flaps. Bring the airplane to level flight attitude and allow airspeed to increase to 125-130 mph. The airplane will sustain flight on the least amount of power at about 125 mph for nearly all weights. This speed tends to lessen the yawing tendency and provides sufficient cooling.

Remember

1. Retract landing gear as soon as you are airborne.

2. Attain critical speed by lowering the nose.

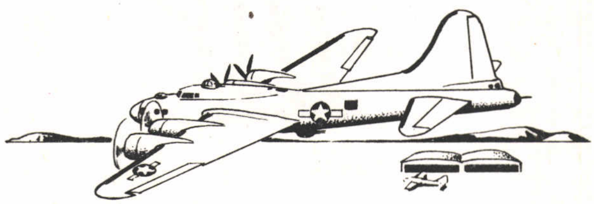
3. Use rudder and minimum aileron to bring dead wing slightly above horizontal.

4. Determine which is the faulty engine. Decide whether to use it or feather it.

5. Complete 3-engine takeoff procedure. Maintain proper engine operating conditions by use of cowl flaps and correct power settings.

6. After recovery and climb, use only as much power as you actually need. Overboosting the good engines may put them within the detonation range and lead to early engine failure.

2-ENGINE FAILURE ON TAKEOFF



Failure of 2 engines on takeoff requires the pilot's and copilot's closest cooperation, but recovery can be successfully accomplished with the proper technique.

If the engine failure occurs during the takeoff run and enough runway remains, close throttles and bring the airplane to a stop.

Remember there are certain limitations below which the airplane will not fly.

Below 115 to 125 mph, depending on the weight of the airplane and the condition of the airplane and engines, the airplane will not accelerate in level flight and may not be able to maintain level flight.

If the weight is above 58,000 lbs., the airplane cannot maintain level flight with two engines.

With two engines out on one side, avoid turns into the dead engines. If turns to that side **must** be made, make them shallow and well coordinated and keep the airspeed at least 20 to 25 mph above the power-off stalling speed for turns.

With an engine out on each side, keep airspeed at least 20 to 25 mph above the power-off stalling speed for turns and make only gentle, well-coordinated turns.

Don't use wing flaps with engines out, except for landing.

Until safe speed has been reached recovery can be effected only by nosing the plane down sharply, applying full power and raising the wheels if it has not already been done, picking up airspeed and raising dead wing to establish directional control as soon as possible. If plane will not hold a constant airspeed above safe airspeed, it indicates that the plane will not climb with the load on board.

It is difficult for a pilot to bring himself to nose down an airplane with only 200-300 feet of altitude available, but you must realize that this is the only possible way to save the airplane.

It is imperative to have all movable loads as near CG as possible.

Recovery

1. Apply rudder, aileron and forward stick until dead wing is well above the horizon, and the nose slightly below the horizon.
2. Apply full power on the good engines. Pilot opens throttles; copilot places propellers in full high rpm, landing gear switch "UP."
3. Do not feather the faulty engines unless you are absolutely sure they will deliver no power and are only creating more drag. **Be sure you know which engines are faulty and feather the correct ones.**
4. Do not bother with trim until recovery is fully accomplished.
5. Do not try to climb before recovery is fully accomplished. Even though you have recovered successfully, you still stand a chance of losing the airplane unless you attain your safe airspeed before beginning the climb.
6. Use a minimum of aileron. Use no aileron at all until safe speed has been attained, unless absolutely imperative. Remember ailerons set up a flap action. The cleaner the wings, the more rapid the recovery. Generally rudder alone will effect the desired correction.
7. Keep a close watch on pressures and temperatures of the good engines, and adjust temperatures with cowl flaps.

Caution

Keep in mind that **stall plus yaw invariably equals spin.** With 2 engines out on one side the airplane will always tend to yaw. Therefore, avoid low speeds.

Maintain speed by holding a safe attitude.

Next in importance is your altitude. If necessary, sacrifice altitude for safe airspeed and attitude.

GO-AROUND WITH ONE ENGINE OUT

Go-arounds with an engine out can be made without too much trouble—if you remember that you don't have 4-engine power. Use all the power available in the good engines as soon as you can, raise the landing gear promptly, and leave wing flaps down ⅓ until you reach an airspeed of at least 140 at a safe altitude.

Follow this procedure:

1. Advance throttles fully as copilot checks the propellers for full high rpm. Maintain directional control with rudder, keeping the dead-engine wing slightly above the horizon.

2. Call for gear up as soon as you are certain that contact will not be made with the runway.

3. Call for ⅓ flaps while the gear is being raised. Remember to raise the nose slightly to overcome the change in lift as the flaps come up.

4. Copilot will call out the airspeed, and when you reach about 140 mph and a safe altitude signal him to retract the flaps fully.

5. Reduce power at a safe altitude, and when flaps are fully up. Remember that you will need considerably more power from each of the three engines than you would if four were operating.

There will be a settling effect caused by loss of lift as the flaps go from ⅓ down to the full up position. Apply slight back pressure on wheel to increase angle of attack and thus compensate for this loss of lift.

Avoid turns into the dead engine, but if such turns are necessary, keep airspeed at least 20 to 25 mph above the power-off stalling speed for turns and make only gentle, well-coordinated turns.

Raise flaps immediately upon application of power. Do not wait until a safe airspeed is reached. You will not reach a safe airspeed with flaps down and only 3 engines operating.

Do not try to get directional control by differentiating throttles. **Open throttles on good engines fully.**

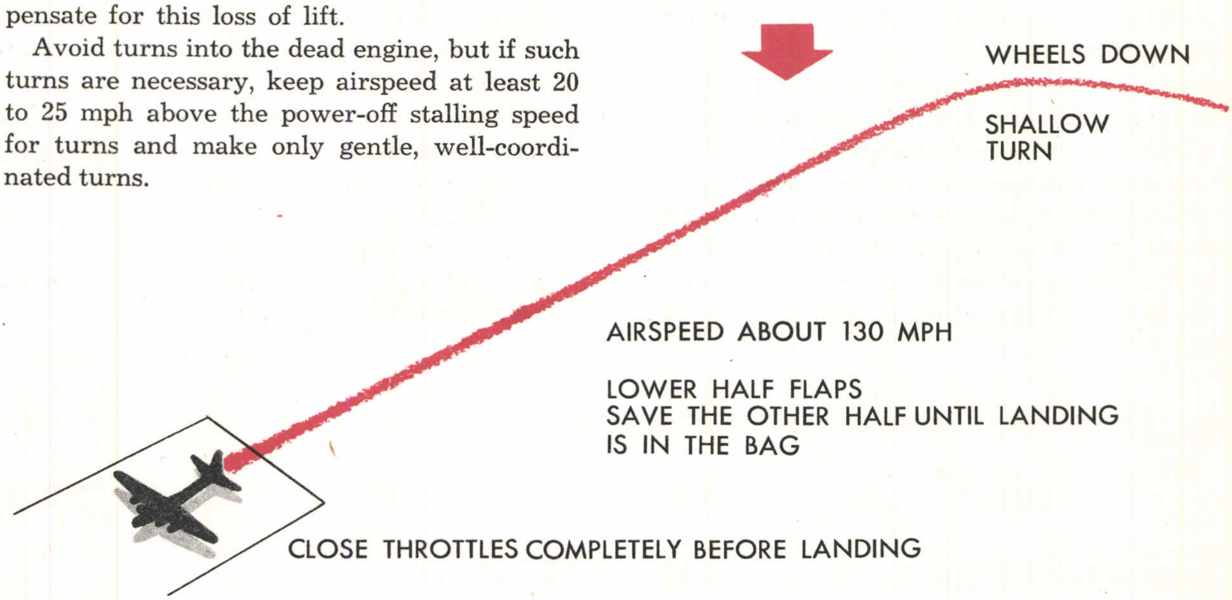
2-ENGINE LANDING

A 2-engine landing will require a technique considerably different from that used for a normal landing.

Make a recovery as outlined under "2-Engine Failure on Takeoff." Then be sure that: (1) recovery is fully accomplished, (2) airspeed is safely above safe speed, (3) the airplane is well under control, and (4) you will not put yourself in a situation where a go-around is necessary.

Approach and Landing

1. Plan your approach so that a shallow turn toward the runway can be started as soon as possible.



2. Set manifold pressure and rpm as required to sustain safe flight.

3. Neutralize trim tabs, so that when power is reduced the airplane will not be off-trimmed. Remember that with power off and two propellers feathered, there will be a yaw toward the **good engines**, as the feathered propellers create less drag than the propellers of the idling engines.

4. Put down landing gear on base leg if the base leg is close to the field; otherwise wait until you are close enough.

5. Approach the runway at a constant rate of descent with airspeed about 130 mph.

6. Lower ⅓ flaps when it is apparent runway will be reached, and at the same time reduce airspeed between 120-125 mph.

7. When you are sure that you will not undershoot the runway, lower the remainder of flaps, further reduce airspeed to about 115 mph. Close throttles completely before landing.

Do not attempt a low dragging approach. Neither direction nor altitude can be maintained with full flaps and wheels down when operating on 2 engines on one side, even with full power.

Do not put flaps down until a landing is in the bag. Remember that dragging up to the field or going around is virtually impossible with wheels and flaps down and only 2 engines operating.

SINGLE-ENGINE OPERATION

Never take it for granted that the B-17 will fly on one engine at any altitude or at any power setting.

If the external condition of the airplane is clean and the operating engine is in good condition, flight may be made for a limited distance. However, the power required is more than one engine can continue to develop indefinitely. Therefore, the crew must be prepared to make a landing when the single operating engine fails.

If you attempt single-engine operation, don't use flaps until the time of landing. Jettison all possible equipment and close all hatches and windows. Feather the 3 dead propellers and close the cowl flaps on the 3 dead engines. Airspeed should be approximately 120 mph, not lower. Have crew members take stations in the cockpit and radio room in order to obtain a normal center of gravity of 28%-30% MAC.

The power required to maintain level flight at 5000 feet for a 40,000-lb. gross weight airplane at 120 mph IAS is slightly less than 1000 thrust Hp. At lower speeds the power required for this gross weight is still lower. One engine may just be able to develop this required power at 5000 feet or lower at a power setting exceeding military power. If all loose guns and equipment are thrown overboard and the fuel is low, the gross weight may be reduced to approximately 40,000 lb.

The practical value of the above procedure is to enable you to prolong your glide and maintain more control of the airplane. Thus, you may be able to reach a field for a landing that might be impossible otherwise.

Remember that with engines feathered there is less drag than with engines idling.

WITH 3 ENGINES FEATHERED YOU WILL FLOAT FARTHER IN YOUR FLARE-OUT FOR LANDING THAN IS USUALLY EXPECTED.

HOW TO BAIL OUT OF THE B-17

When an emergency develops and it becomes necessary to abandon the airplane in flight, there is no time for confusion or second guessing. Procedure of the entire crew in bailing out of the airplane must be almost automatic. Each crew member must know (1) his duties, (2) through what hatch he is supposed to exit, and (3) how to bail out, open his parachute, and land. (See PIF.)

As airplane commander, your first responsibility is to be sure that your crew is thoroughly trained, by regular ground drill, in the proper procedure for bailing out of the B-17.

Before taking off on any flight make absolutely sure that:

1. An assigned parachute, properly fitted to the individual, is aboard the airplane for each person making the flight.
2. The assigned parachute is convenient to the normal position in the airplane occupied by the person to whom it is assigned.
3. Each person aboard (particularly if he is a passenger or a new crew member who has not taken part in your regular ground drill) is familiar with bailout signals, bailout procedure, and use of the parachute.

DUTIES OF THE CREW

The Airplane Commander

1. Notify crew to stand by to abandon ship. The bell signal consists of three short rings on alarm bell. At first alarm all crew members put on parachutes.
2. Notify crew to abandon ship. Bell signal consists of one long ring on alarm bell.
3. Clear bomb bay of tanks and bombs, using emergency release handle.
4. Turn on autopilot.
5. Reduce airspeed if possible. Hold ship level.

Copilot's Duties

1. Assist airplane commander as directed.

Navigator's Duties

1. Determine position, if time permits.
2. Direct radio operator to send distress message, giving all pertinent information.
3. Stand by emergency exit in nose of airplane.

Bombardier's Duties

1. Assist navigator.
2. Stand by emergency exit in nose of airplane.

Engineer's Duties

1. Assist pilot as directed.
2. Notify pilot when crew in nose has abandoned the airplane.
3. Stand by to leave via bomb bay immediately after crew in nose has abandoned airplane.

Radio Operator's Duties

1. Transmit distress signal and information received from navigator.
2. Stand by to leave via bomb bay.

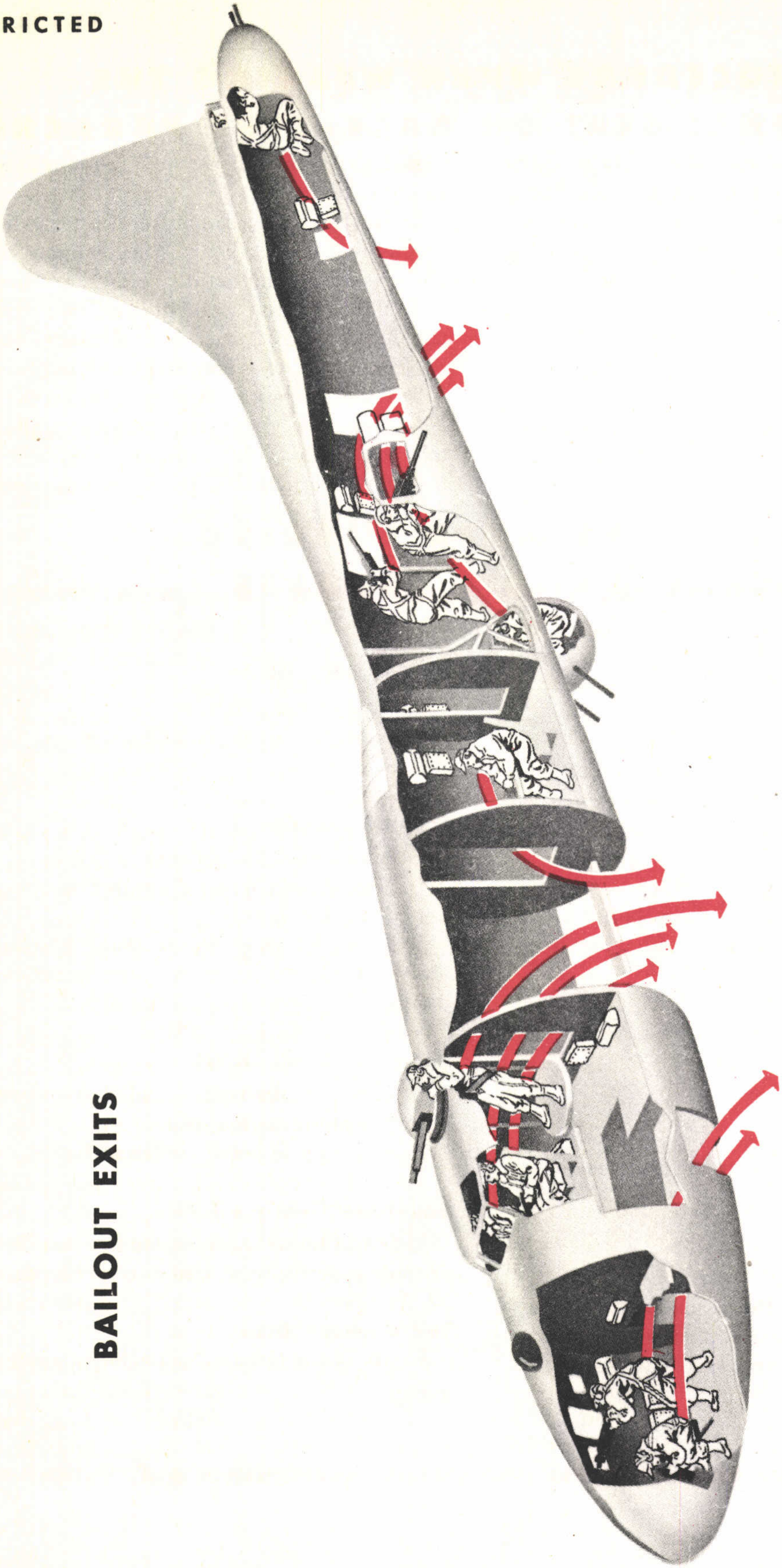
Ball Turret Gunner's Duties

1. Stand by to leave via main entrance door, or most practical rear exit as occasion demands.

Tail Gunner's Duties

1. Stand by to leave via tail gunner's emergency exit.

BAILOUT EXITS



BAILOUT PROCEDURE WHEN WEARING THE CONVENTIONAL SEAT OR BACK-TYPE PARACHUTE

Pilot—Exits through forward end of bomb bay. (Alternate exit, out front entrance door.) Is last to leave plane.

Copilot—Exits through forward end of bomb bay.

Bombardier—Exits through front entrance door.

Navigator—Exits through front entrance door.

Upper Turret Gunner—Exits out forward end of bomb bay.

Radio Operator—Exits through after end of bomb bay.

Right Waist Gunner—Exits through main entrance door.

Left Waist Gunner—Exits through main entrance door.

Ball Turret Gunner—Exits through main entrance door.

Tail Gunner—Exits through small emergency door in tail.

BAILOUT PROCEDURE WHEN WEARING QUICK ATTACHABLE CHUTE HARNESS

When the order is given over the intercom to "Abandon airplane," each crew member will remove the one man life raft and chest type parachute from their respective positions near his station, snap them onto his QAC harness, and exit through the hatch specified. The following instructions, used with the diagram, show the positions of the one man life rafts and the parachutes, and correct exit hatch. Each should check the others to make sure that all are wearing a full complement of equipment, securely fastened. Whenever possible, jump from the after end of the hatch. Remember, a life vest should be worn under the QAC harness on all over-water flights. The lanyard on the one man life raft should be snapped onto the D-ring on the life vest.

Periodic ground drills will familiarize your crew members with the operation of the QAC harness and the order of bailout.

Pilot—Parachute mounted on floor, directly behind seat in pilot's cabin. One man life raft worn in seat position. Pilot is to exit through forward end of bomb bay. (Alternate exit, out front door.) Last to leave plane.

Copilot—Parachute mounted on floor directly behind copilot's seat in pilot's compartment. One man life raft worn in seat position. Exits through forward end of bomb bay. (Alternate exit, through front entrance door.)

Bombardier—Parachute mounted in navigator's compartment on starboard wall directly opposite navigator about halfway up on wall. One man life raft mounted in navigator's compartment near floor on starboard side, half the distance forward from bulkhead. Exit through front entrance door.

Navigator—Parachute mounted on bulkhead armor plating directly above door, on inner side of navigator's compartment. One man life raft mounted alongside and to rear of bombardier's life raft. Exits through front entrance door.

Upper Turret Gunner—Parachute mounted on floor just forward of bomb bay bulkhead on port side. One man life raft mounted on forward wall of bomb bay bulkhead in turret compartment, directly below entrance to bomb bay. Exits through forward end of bomb bay.

Radio Operator—Parachute mounted on starboard wall just forward of rear bulkhead of radio compartment, three-quarters of the way up side of wall. One man life raft mounted directly beneath parachute. Exits through after end of bomb bay.

Right Waist Gunner—Parachute mounted on starboard wall just forward of rear door and even with top of door. One man life raft mounted directly beneath parachute. Exits through main entrance door.

Left Waist Gunner—Parachute mounted on starboard wall just forward of rear door and even with top of door. One man life raft mounted directly beneath parachute. Exits through main entrance door.

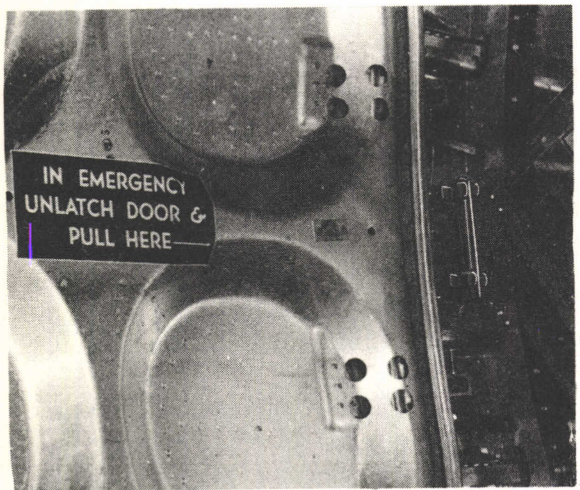
Ball Turret Gunner—Parachute mounted on aft starboard side of rear bulkhead of radio compartment, about even with top of door. One man life raft mounted directly beneath parachute. Exits through main entrance.

Tail Gunner—Parachute mounted on starboard wall immediately aft and slightly above rear gunner's escape hatch. One man life raft mounted directly beneath parachute. Exits through small emergency door in tail.

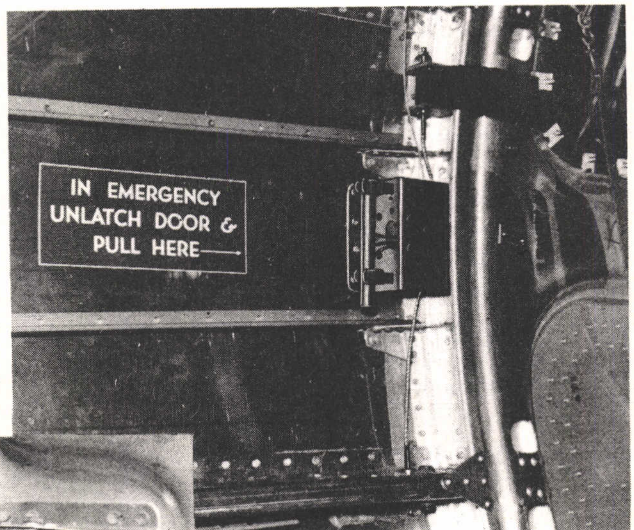
Any other crew member, waist gunners and passengers will leave via main entrance door or most practical rear exits, as occasion demands.

Practice Bailout Procedure

After explanation of procedure, have the crew go to the airplane and practice abandoning airplane on the ground. Too much emphasis cannot be placed on the proper procedure, and on every man knowing his exit.



EMERGENCY RELEASE NAVIGATOR'S HATCH



EMERGENCY RELEASE WAIST DOOR

EMERGENCY RELEASE TAIL GUNNER'S HATCH

HOW TO DITCH THE B-17

Ditching drill is the responsibility of the pilot. Duties should be studied, altered if necessary to agree with any modifications, memorized, and practiced until each member of the crew performs them instinctively.

The pilot's warning to prepare for ditching should be acknowledged by the crew in the order given here—copilot, navigator, bombardier, flight engineer, radio operator, ball turret gunner, right waist gunner, left waist gunner, and tail gunner, i.e., "Copilot ditching," "Navigator ditching," etc.

Upon acknowledgment, crew members remove parachutes, loosen shirt collars and remove ties and oxygen masks unless above 12,000 feet. When preparations for ditching are begun above 12,000 feet, main oxygen supply or emergency oxygen bottle is used until notification by the pilot. All crew members wearing winter flying boots should remove them. No other clothing should be removed.

Releases on life rafts should not be pulled until the plane comes to rest.

Beware of puncturing rafts on wing and horizontal surfaces while launching. The life rafts should be tied together as soon as possible.

Injured men should get first consideration when leaving the airplane.

Life vests should not be inflated inside the plane unless the crew member is certain that the escape hatch through which he will exit is large enough to accommodate him with the vest inflated.

When personnel are in life raft, stock of rations and equipment should be taken by the airplane commander (or copilot). Strict rationing must be maintained. Flares should be used sparingly and only if there is a reasonable chance that they will be seen by ships or aircraft. Don't forget the Very pistol.

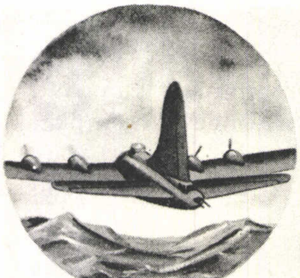
Lash the life rafts together.

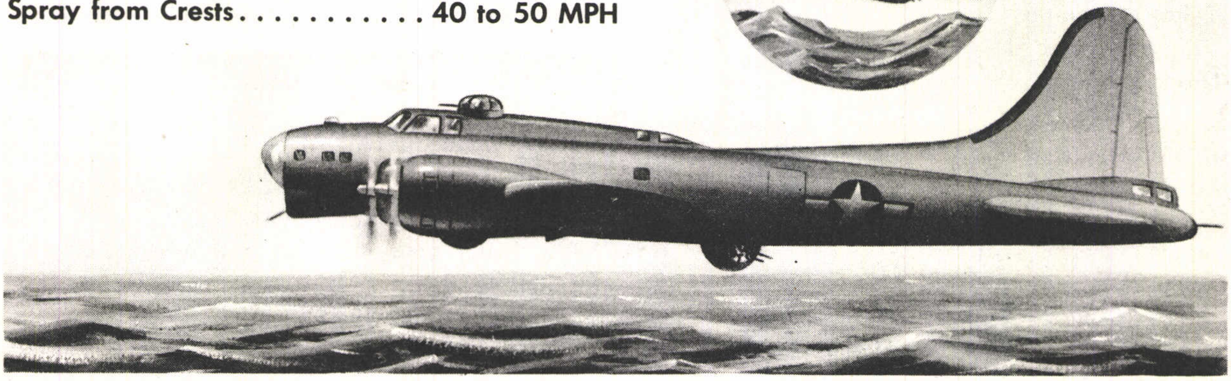
Approach and Touchdown

Pilot determines direction of approach well in advance. Touch down parallel to lines of crests and troughs in winds up to 35 mph. Ditch into wind only if wind is over 35 mph or if there are no swells. Use flaps in proportion to power available to obtain minimum safe forward speed with minimum rate of descent. In every case try to ditch while power is still available. Touch down in a normal landing attitude.

HOW TO DETERMINE WIND SPEED

A Few White Crests	10 to 20 MPH
Many White Crests	20 to 30 MPH
Foam Streaks on Water	30 to 40 MPH
Spray from Crests	40 to 50 MPH





DUTIES OF THE CREW

A crew member and an alternate will be designated by the pilot before flight to take the emergency radio transmitter and all other emergency equipment to the radio room before ditching and will be responsible for getting their equipment to the life rafts.

Airplane Commander

1. Give "Prepare for ditching" warning over interphone; give altitude; sound ditching bell signal of six short rings.
2. Fasten safety harness.
3. Open and close window to insure freedom of movement. Place ax handy for use in case of possible jamming.
4. Order radio operator to ditching post.
5. Just before impact, order the crew to "brace for ditching." Give long ring on signal bell.
6. Release safety harness and parachute straps. Exit through side window when airplane comes to rest. Inflate life vest.
7. Proceed to left life raft, cut tie ropes. Take command.

Copilot

1. Assists pilot fasten safety harness.
2. Fastens own safety harness, opens and closes right window to insure freedom of movement.
3. Releases safety harness, parachute straps, exits through right window when plane comes to rest. Inflates life vest.
4. Proceeds to right life raft, cuts ropes. Takes command.

Navigator

1. Calculates position, course, speed, giving this information to the radio operator. Destroys secret papers. Gathers maps and celestial equipment. Gives wind and direction to the pilot.
2. Proceeds to radio compartment.
3. Assumes ditching position.
4. Exits through radio hatch and goes to left life raft after airplane has come to rest.

Bombardier

1. Jettisons bombs, closes bomb bay doors, destroys bombsight, goes to radio compartment, closing compartment door. Takes first-aid kits to radio compartment.
2. Takes position, partially inflates life vest by pulling cord on one side.
3. Directs and assists exit of men. Stands above radio hatch to receive survival equipment such as emergency radio, signal set, ration kits, etc.
4. Goes to right life raft.

Flight Engineer

1. Jettisons ammunition and unnecessary loose equipment, turns top turret guns to depressed position pointing forward.
2. Goes to radio compartment. Lowers the radio hatch and moves it to the rear of the plane, jettisons loose equipment in radio compartment, and slides back top gun.
3. After airplane has come to rest, exits through radio hatch and goes to left life raft.

Radio Operator

1. Switches on liaison transmitter (tuned to MFDF) sends SOS, position and call sign continuously, turns IFF to distress, remains on intercom, transmits all information given by navigator.
2. Obtains MFDF fix, continues SOS, remains on intercom.
3. On pilot's order clamps key, takes ditching position, inflating life vest partially, remains on intercom, repeating pilot's "Brace for ditching" to crew.
4. Goes to right life raft.

Ball Turret Gunner

1. Turns turret guns aft, closes turret tightly, goes to radio compartment.
2. Pulls both life raft releases as aircraft comes to rest.
3. Goes to left life raft.
4. Assists in inflating raft and inspects for leaks, applying stoppers if necessary.

Right Waist Gunner

1. Jettisons his gun, ammunition, all loose equipment.
2. Closes right waist window tightly, goes to radio compartment.
3. Takes position, partially inflates vest.
4. Assists in inflating right life raft, inspects for leaks, applying stoppers if necessary.

Left Waist Gunner

1. Jettisons his gun, ammunition, loose equipment, closes left waist window, goes to radio compartment.
2. Partially inflates vest.
3. Goes to right life raft.

Tail Gunner

1. Jettisons ammunition; goes forward to radio compartment.
2. Takes position, partially inflates life vest.
3. Goes to left life raft.

CREW POSITIONS FOR DITCHING

The positions illustrated should best enable crew members to withstand the impact of crash landings on either land or water. On water two impacts may be felt, the first a mild jolt when the tail strikes, the second a severe shock when the nose strikes the water. Positions should be maintained until the airplane comes to rest. Study them carefully.

Emergency equipment for use in the life raft should be carried to crash positions. Any equipment carried free must be held securely during ditching to prevent injury.

Parachute pads, seat cushions, etc., should be used to protect the face, head, and back.

1. Jettison bombs, ammunition, guns and all loose equipment not necessary for survival and secure that equipment which might cause injury. Close bomb bay doors and lower hatches. If there is not enough time to release bombs or depth charges place them on "SAFE." Retain enough fuel to make a power landing.
2. Navigator calculates position, course, and speed and passes data to radio operator. Latter tunes liaison transmitter to MFDF and sends SOS, position and call sign continuously. Radio operator also turns IFF to distress and remains on intercom; clamps down key on order to take ditching post.

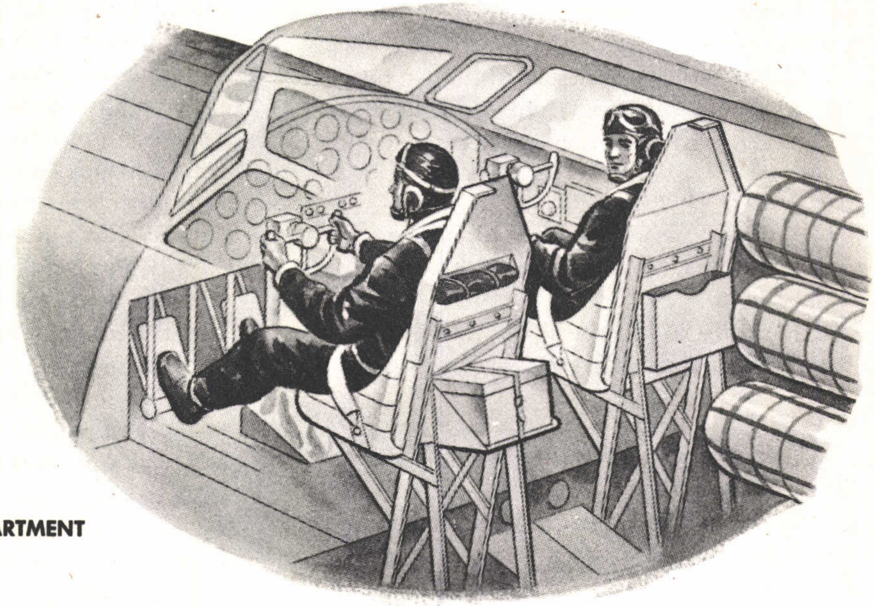
Approved Braced Positions

For any crew member who for any reason cannot ditch in his normal position or for passengers, positions are as follows:

1. Secured by a safety harness.
2. Seated with back against a forward bulkhead, hands clasped behind head.
3. Lying with back on floor, feet braced against a forward bulkhead, knees flexed.
4. Braced against a ditching belt.

See Illustration next page

CREW POSITIONS FOR DITCHING



PILOT'S COMPARTMENT

RADIO OPERATOR'S COMPARTMENT

CRASH LANDINGS

No procedure can be established which will fit all cases. The following is a summary of the steps which should be taken if time permits. The airplane commander will exercise his authority to alter this procedure wherever necessary.

Airplane Commander Will

(1) Notify crew by interphone or oral communication between crew members that crash landing will be made.

(2) Notify bombardier to release bombs or bomb bay tanks. (If possible, drop them in uninhabited or enemy territory.) Then close the bomb bay doors.

(3) Make a normal slow landing, with flaps down and landing gear up.

The Copilot Will

(1) Turn master switch and battery switches "OFF" after operation of necessary electrical equipment such as flaps, radio, gear, landing lights, etc., **when it is certain that there will be no further need for the operating engines.**

(2) Assist airplane commander as directed.

The Bombardier Will

(1) Check with airplane commander to determine of auxiliary gas and/or bombs are to be dropped.

(2) Release bombs or tanks. Close bomb bay doors.

(3) Proceed to radio compartment.

The Engineer Will

(1) See that each man in the radio compartment is properly braced for impact.

(2) See that doors from radio compartment of airplane into bomb bay, and from bomb bay into control cabin are locked open.

(3) See that all emergency exits are opened, but not freed from airplane. A door that is cast free may damage the control surfaces.

The Navigator Will

(1) Determine position if time permits.

(2) Proceed to rear compartment.

(3) Direct radio operator to send distress message, giving all pertinent information.

Abandoning Airplane Following Crash Landing on Land

(1) All preparation for abandoning ship has been made during the approach. After landing, little can be done except to get out as quickly as possible.

(2) Crew members will take fire extinguishers, if available, with them when leaving the airplane. This may enable them to put out a small fire and rescue personnel trapped in the airplane.

(3) Dispose of all classified material in accordance with Army Regulation 380-5.

EQUIPMENT

Fuel System

The fuel system of the B-17 consists of 4 independent fuel supplies of approximately equal capacities, each feeding one engine. There are 3 tanks in each wing, with provisions for 2 additional groups of outer wing feeder tanks. These outer wing feeder tanks (Tokyo tanks) are composed of 9 individual, collapsible self-sealing cells per wing. The fuel supply can also be increased by auxiliary installations of releasable fuel tanks in the bomb bay.

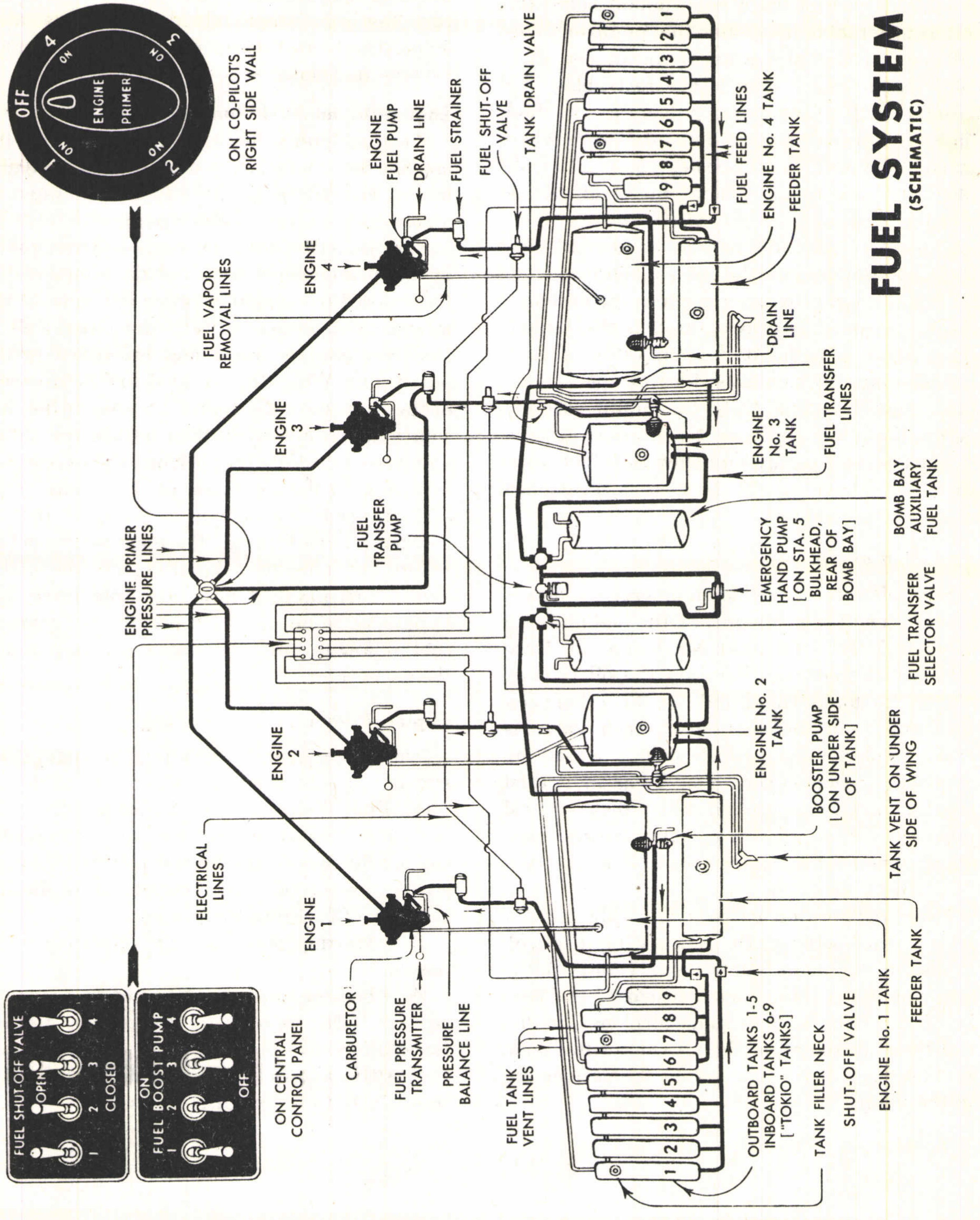
The fuel in any tank is available to any engine supply tank in the airplane through a **fuel transfer system** consisting of 2 **selector valves** and an **electrical transfer pump.**

Some airplanes may still have a **hand transfer pump** in the bomb bay as an emergency transfer medium. **Fuel booster pumps** in the outlets of the 4 major wing tanks eliminate vapor lock between the tank and the engine fuel pump. They also provide fuel to the carburetor when the engine pump fails. An electrically controlled **fuel shut-off valve** is installed in the line beyond the fuel booster pump to prevent fuel flow through a severed fuel line.

FUEL CAPACITY

FUEL TANKS	U.S. GALLONS EACH	TOTAL U.S. GALLONS
No. 1 and No. 4 engines	425	850
No. 2 and No. 3 engines	213	426
Feeders (No. 2 and No. 3 engines)	212	424
Outboard Wing (No. 1 and No. 4 engines)	270	540
Inboard Wing (No. 2 and No. 3 engines)	270	540
Total Fuel		2780
Bomb Bay Tanks (2)	410	820
Total Fuel (Special)		3600

FUEL SYSTEM
(SCHEMATIC)



Booster Pump

The booster pumps (at the outlet on the underside of each of the 4 main tanks) serve to: (1) assure fuel to the engine fuel pump on take-off and landing, and when flying at less than 1000 feet or more than 10,000 feet above the ground; (2) prevent vapor lock in the fuel lines; (3) provide fuel to the carburetors when starting engines. No. 3 booster pump also supplies pressure to the primer pump at engine starting.

They are electrically operated and controlled by toggle switches on the central control stand. At high altitudes, bubbles form in the gasoline. As the gasoline is drawn through the funnel, the centrifugal action of the pump throws these bubbles out through the sides of the screen, back into the tank. Only the liquid gasoline enters the pump and is sent to the fuel system.

Turn booster pumps on below 1000 feet; turn them on above 10,000 feet as a safeguard against vaporization.

Fuel Shut-off Valves

Shut-off valves provide an emergency means of shutting off fuel flow in case the fuel lines are severed. Valves for tanks No. 1 and No. 4 are forward of the tanks between the oil coolers. Valves for tanks No. 2 and No. 3 are between the tanks and the rear spar. Each valve is spring-loaded to stay open and is closed by means of a solenoid controlled by an individual toggle switch in the cockpit. When the electrical power is turned off, these valves spring open, even when the toggle switch is in the "CLOSED" position.

Four fuel shut-off valves control the gravity flow of fuel between the outer wing (Tokyo) tanks and the main fuel systems. Control units are mounted on the forward side of the rear bomb bay bulkhead in some airplanes, in the radio compartment on the aft side of the same bulkhead in others. The valves themselves are in the wings.

Gas should be drained from the Tokyo tanks in one operation, after main fuel tanks get down to approximately 100 gallons. When the fuel has been completely drained (this takes about 1¼ hours) close the valves to prevent reverse fuel flow.

Engine-Driven Fuel Pump

The fuel pump forces sufficient fuel to the engines for operation at altitudes up to 10,000 feet. Above 10,000 feet, the fuel pump must be assisted by the fuel booster pump.

Fuel is drawn into the engine-driven pump by the paddlewheel action of the vanes within the pump. Fuel caught between the vanes at the inlet port is forced between the inner wall of the liner and the rotor and is carried to the outlet port. When the pumped fuel is in excess of the carburetor's demand, the excess fuel has sufficient pressure to lift the pressure-regulating valve from its seat. This permits the excess fuel to escape to the inlet side of the pump.

Fuel used in starting is pumped by the booster pumps through the engine-driven fuel pump. The fuel enters the inlet port (the engine driven fuel pump is now idle) and forces the bypass valve open, which permits the starting fuel to flow through the engine-driven pump to the carburetor.

Engine Primer

Provides a means of priming the engines for starting. It is on the floor to the right of the co-pilot. Fuel is drawn into the primer from the nacelle No. 3 fuel strainer and is forced into the top 5 cylinders of the engine selected. Several strokes are usually necessary to draw the initial flow of fuel into the primer.

(See starting procedure for operating information.)

Fuel booster pump for No. 3 engine must be turned "ON" to operate the primer. Do not leave plunger of engine primer in the up position as this allows fuel to pass directly through the primer to the engine selected.

Fuel Transfer Selector Valves

Two selector valves direct fuel from any tank on one side of the airplane to any tank on the opposite side, exclusive of the inboard feeder tanks and the Tokyo tanks. To direct fuel from one tank to another **on the same side** of the airplane center line, the valves must first be set to transfer the fuel to a tank on the opposite side and then transfer it back across the center line to the desired tank.

The 2 selector valves are on the aft side of bulkhead in the rear of the pilot's compartment, one on the right and one on the left side of the door. The control handles are on the forward side of the bulkhead. When the shaft is turned, the cam also turns, and presses down one of the 3 plungers which open the desired valve. The fuel always enters the selector valve at one port and will exit from only one of the other 3 ports at one time.

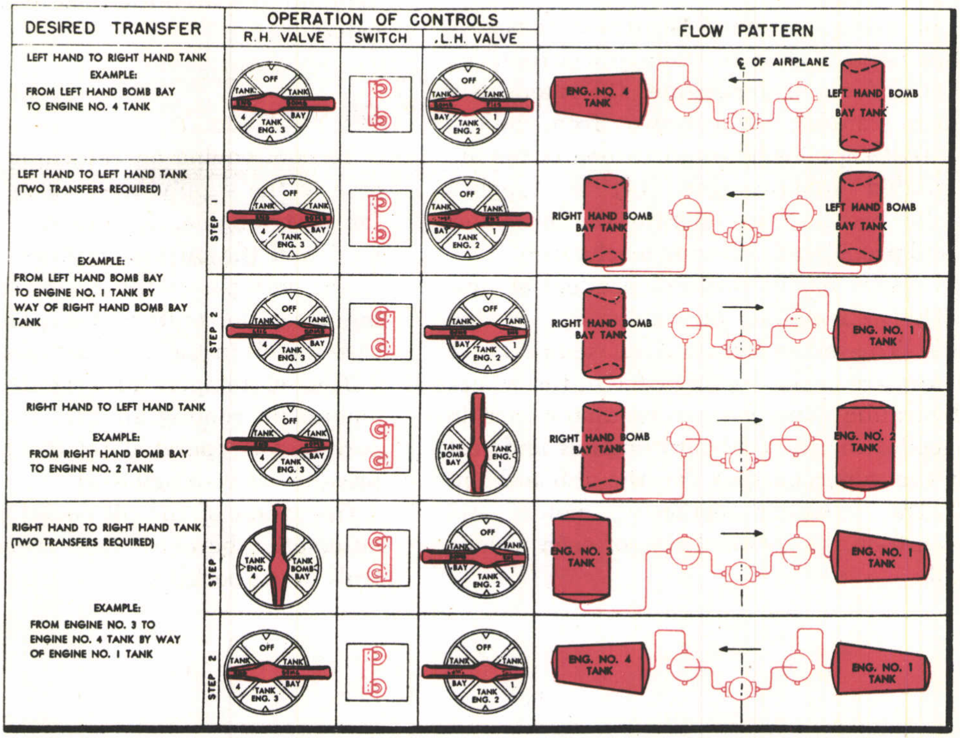
An electric switch, installed as a safety feature on the handle of each of the 2 selector valves, closes the circuit to the pump motor whenever any valve port is opened. This eliminates any possible damage to the motor or selector valve in case all of the ports in one valve are closed.

1. Check the fuel transfer for proper operation at each preflight inspection.

2. Transfer fuel from the bomb bay tanks to the wing tanks as soon as possible after takeoff to check transfer system for operation. If you know that the transfer system is in operating condition, there is no need to hurry the transfer of fuel from bomb bay to wing tanks. Fuel in the bomb bay tank is **disposable load**—the most desirable kind of load to have if and when an emergency arises.

Fuel Transfer Pump

The fuel pump is used in conjunction with the transfer valves to transfer fuel from the



auxiliary tanks to the main wing tanks, or from one wing tank to another. It is in the forward end of the bomb bay under the step on the catwalk between the fuel transfer selector valves.

Hand Transfer Pump

A hand transfer pump on the rear bulkhead of the bomb bay (on some airplanes, removed on most) provides a means of transferring fuel in case the electric-driven fuel transfer pump fails, or transferring fuel from drums to airplane tanks. The pump handle is turned in a clockwise direction. For transferring fuel in flight, disconnect the hose from the fuel transfer pump connection at fuel transfer selector valve. Connect the suction line of the hand pump to the selector valve on the side of the airplane from which the fuel is to be removed. Connect the pressure line of the hand pump to the selector valve on the side of the airplane to which the fuel is to be transferred.

Oil System

The oil system of the B-17 airplane has several functions: (1) it provides lubrication for wearing surfaces of the engine; (2) it aids as a coolant in transferring heat away from the engine; (3) it supplies hydraulic pressure for the oil-regulated supercharger; (4) it supplies hydraulic pressure to operate the propeller pitch and propeller feathering mechanism.

Each engine has its own independent oil system. The self-sealing oil tanks are in the nacelles. The oil cooler and oil temperature regulators are in the leading edge of the wings. The hydraulic supercharger regulators are in the nacelles for the outboard engines and just aft of the superchargers for the inboard engines. The propeller feathering motors and pumps are on the forward side of each nacelle firewall.

Operation

Oil flows from the tank by gravity and by suction from the engine-driven oil pump, which forces the oil under pressure to the various moving parts of the engine. The oil then drops down to the sump, where it is picked up by the engine-driven scavenging pump and forced through the oil cooler. The oil then returns to the tank.

The oil lines to the supercharger regulators are tapped off the engine accessory cases on the pressure side of the pump. This oil circulates under pressure to the regulator and then returns to the engine, where it drains into the sump.

The propeller feathering oil line is tapped off the main oil line from the tank to the engine or the oil tank sump. The propeller feathering pump draws the oil and forces it under pressure to the propeller feathering valve in the propeller dome.

All the oil lines are lagged (insulated) in order to prevent oil cooling and congealing at high altitude.

An oil dilution fuel line is tapped into the main oil line from the tank at the Y-cock drain valve.

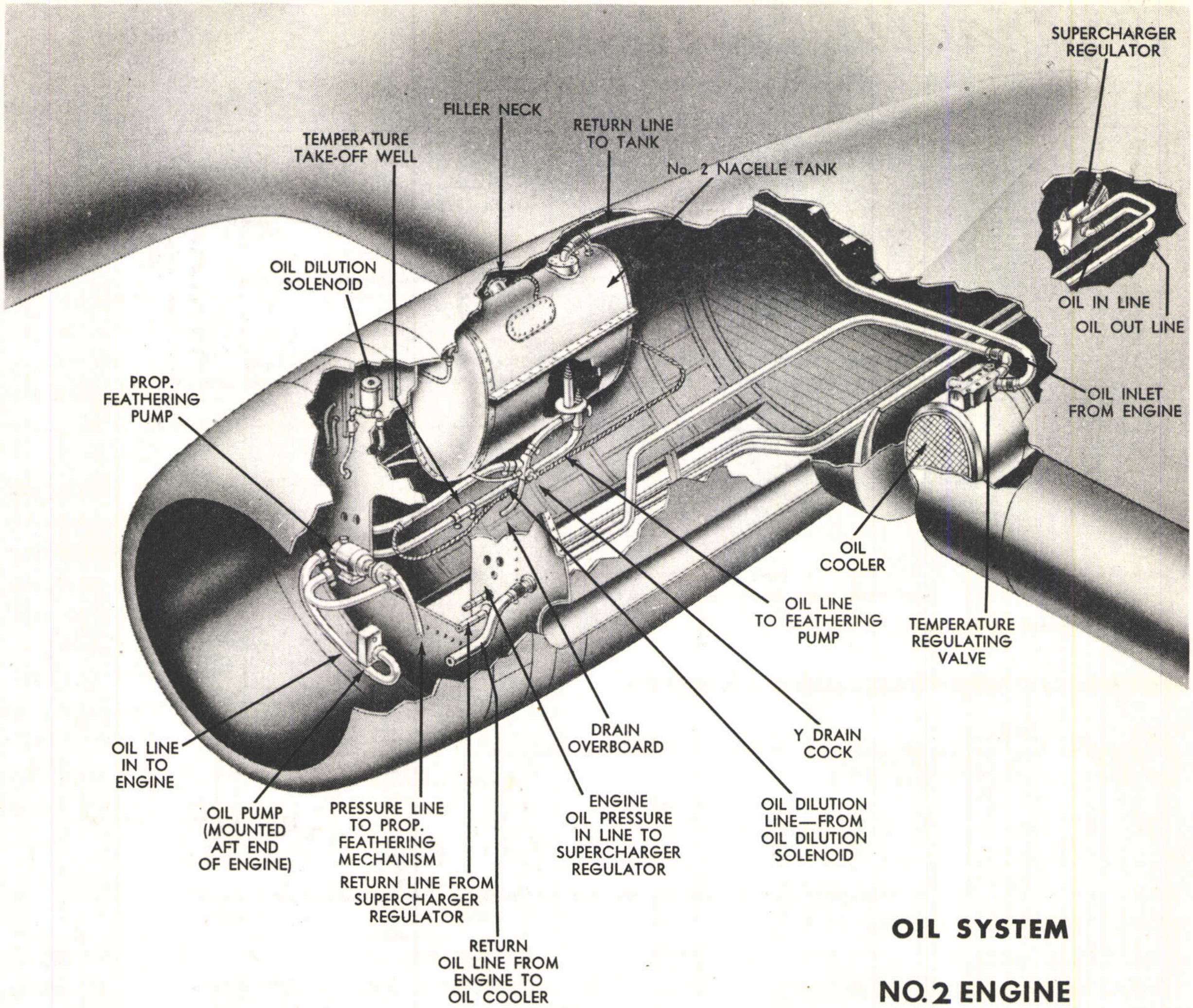
Oil Cooler

To cool engine oil returning from the crank case to the supply tank, there is an oil cooler for each engine. It consists of the core and muff and the oil temperature regulator.

The core passes the oil through a large cooling area; the muff is a bypass of the core in case the oil in the core becomes congealed.

The oil temperature regulator controls the amount of cooling air that passes through the core and is operated by the temperature and pressure of the engine oil.

Operation of the oil cooler shutters is fully automatic; therefore there are no oil cooler controls in the cockpit.



OIL SYSTEM

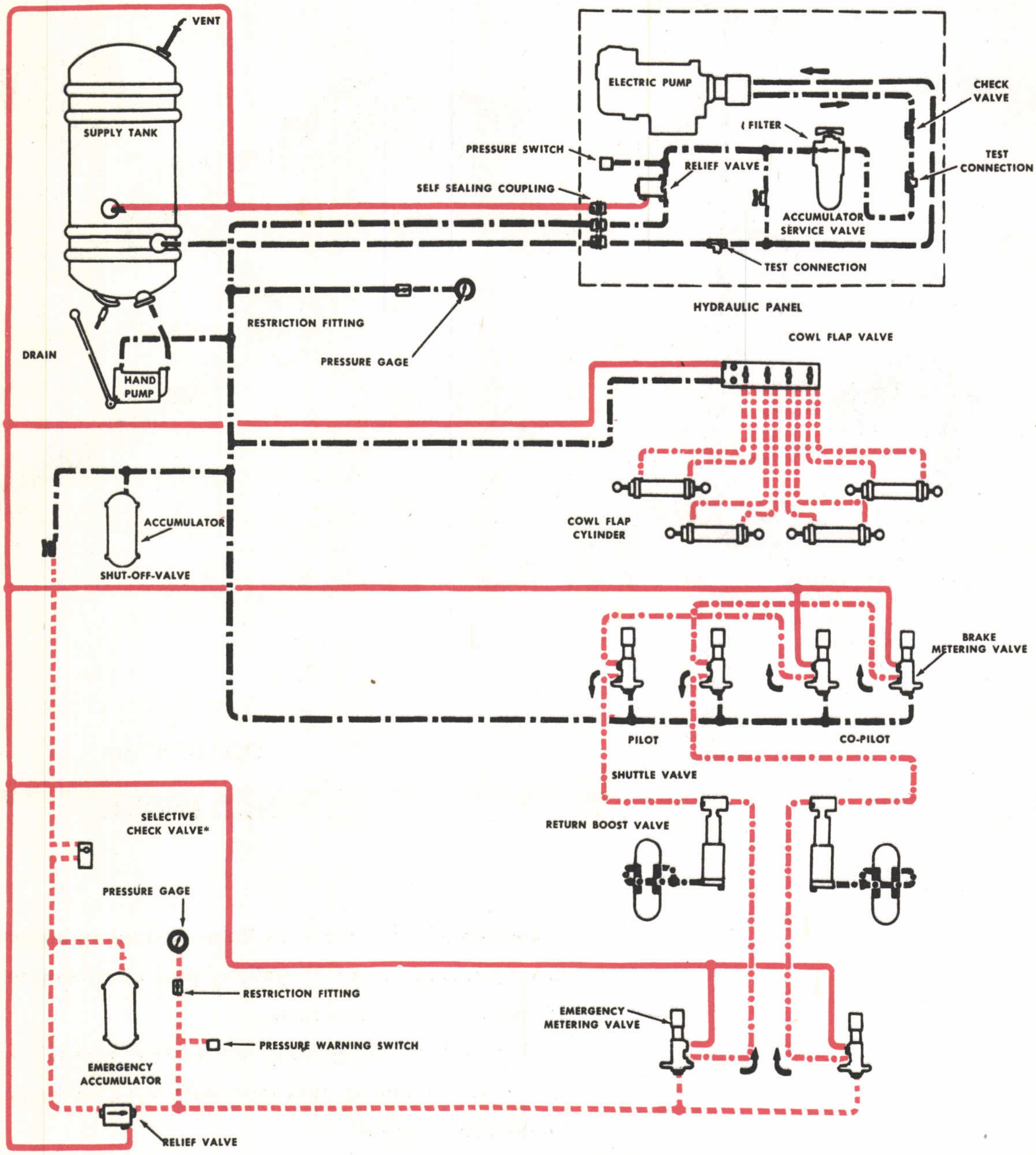
NO. 2 ENGINE

Each engine is equipped with a self-sealing oil tank having a capacity of 37 gallons plus approximately 10 per cent expansion space.

The total of 148 gallons for all four tanks is required for maximum fuel load with wing tanks and bomb bay tanks full.

Fill oil tanks with Specification No. AN VV-0-446, grade 1120 for normal operations, grade 1100A for cold weather.

Hydraulic System



NOTES
*VALVE NOT INSTALLED ON SOME AIRPLANES.
INDICATED METERING VALVE FLOW APPLIES BRAKES.
RELEASE OF BRAKES REVERSES FLOW.
PARKING BRAKES OPERATED FROM CO-PILOT'S METERING VALVES.

SUPPLY LINES
PRESSURE LINES
RETURN LINES
EMERGENCY BRAKE SYSTEM LINES
PRESSURE AND RETURN LINES (ALTERNATELY)

NOTE: FOR AIRPLANES WITH DUAL DUPLEX BRAKES.

The hydraulic system on the B-17 operates the cowl flaps and the wheel brakes.

Operating pressures of the system are from 600 to 800 lb. sq. in. These pressures are developed by an electrically driven hydraulic pump which serves both the main and emergency systems. However, in all flight operations, the emergency system is shut off from the main system and relies on the hydraulic fluid stored in the emergency accumulator for its source of power.

System Fluid Capacity

The complete hydraulic system (including reservoir, accumulator, and lines) has a fluid capacity of approximately 6 gallons. The reservoir, or supply tank, which has a storage capacity of 1.75 gallons, has two outlets. One, 5 inches from the bottom, feeds the electric hydraulic pump; the other, at the bottom of the tank, feeds the hand pump. Thus there is about .85 gallons of fluid in reserve for the hand pump.

The fluid should reach the full mark on the dip stick when system pressure is 800 psi. Service with AN VV-0-366a fluid.

Operation

When the hydraulic pump switch on the pilot's control panel is in the "AUTO" position, pressure is automatically regulated by a pressure cut-out switch, starting the pump when the pressure drops to 600 lb., and stopping the pump when the pressure builds up to 800 lb. In case the automatic pressure switch fails, maintain pressure by holding the hydraulic pump switch in the "MANUAL" position. A relief valve opens if the pressure in the system reaches 900 lb.

Should leakage occur in the hydraulic system, stop the pump to prevent loss of fluid. Remove the hydraulic pump switch fuse in the main fuse panel in the cockpit, or disconnect the electrical receptacle at the pressure switch.

In some airplanes the hydraulic pump is controlled by an on-off switch on the pilot's control panel. This switch must be "ON" to maintain pressure.

Brakes

The brake assemblies are on the inboard side of the main landing wheels, except in B-17G and late F's, which have dual brakes.

Hydraulic pressure applied from the cockpit expands the expander tubes, forcing the brake lining against the brake.

Apply the brakes as little as possible and then only for short intervals. Excessive and unnecessary use of the brakes will generate sufficient heat to cause failure of the expander tubes and cracking of the brake drums and wheels. Taxi the airplane with the inboard engines shut off and maintain directional control with the outboard engines.

Do not leave the parking brake on while the brakes are hot from previous use. This will cause the heat in the drums to pass through the lining and literally cook the expander tube, which then becomes brittle. Do not apply hydraulic pressure to the brake with the wheel removed, as this will burst the expander tubes.

Emergency Brake System (Not installed on most airplanes)

A spare accumulator and auxiliary metering valve provide emergency brake operation. A red warning lamp on the pilot's instrument panel lights when pressure in the emergency system falls to approximately 700 lb. sq. in. To charge the emergency accumulator, open the manual shut-off valve. If a selective check valve is installed, place it in the "SERVICING" position unless it is lock-wired in the "NORMAL" position. (These units are on the right side wall at the rear of the pilot's compartment.) Build up 800 lb. pressure in the system, then return the selective check valve to "NORMAL" and close the manual shut-off valve.

Pressure Gages

Pressure in the service and emergency brake systems is indicated by 2 gages on the pilot's instrument panel.

Hand Pump

A hand pump on the side wall at the right of the copilot is used to supply pressure for ground operations and to recharge the accumulators if the electric pump fails.

Electrical System

Electrical power operates much of the auxiliary equipment in the airplane, such as the turrets, landing gear, wing flaps, instruments, bomb bay doors, and other miscellaneous equipment. Various units of the electrical system are distributed throughout the entire airplane. (See diagram.)

A 24-volt direct-current system is used in the B-17. Type Mg-149 inverters are installed to furnish alternating current for all equipment requiring alternating current for its operation.

Control of the electrical system is accomplished mainly at the pilot's and copilot's stations. The bombardier and the navigator control the units necessary to their jobs.

Fuse shields, accessible in flight, are on the bulkhead to the rear of pilot's seat and at station No. 6. There are also fuse shields in each nacelle. An alternating current fuse shield, accessible in flight, is on the floor below the pilot.

Generators

The generators on the accessory panel on the rear of each engine are the primary source of electrical power. They keep the batteries charged and provide power for electrical equipment. The generators are driven by the engines at 1½ times engine speed. They deliver up to 200 amperes at 28.5 volts at engine speeds above 1350 or 1400 rpm.

Auxiliary Power Equipment

A gasoline engine-driven generator unit, in the rear of the fuselage and for use on the ground, and in the air for emergencies, supplies auxiliary electric power for battery recharging or limited radio operation.

Since it is inadvisable to deplete the batteries unnecessarily, another source of energy should be used in starting the engines. Use the auxiliary power unit wherever practicable for ground operation. This not only saves the batteries but charges them, and use of this unit assures that it is in serviceable condition if it should be needed in emergency.

If you cannot use the auxiliary unit, start engines with battery carts or with a field energizer. The receptacle for external power is on the underside of the fuselage, near the navigator's escape hatch. Saving the batteries is especially important in preflight and cold weather.

AC System

Alternating current for the autosyn instruments, drift meter, radio compass, and warning signals transformer is furnished by either of 2 inverters, one of which is a standby for the other. One inverter is under the pilot's seat and the other under the copilot's seat. A single-pole, double-throw switch on the pilot's control panel controls the DC power to the inverters and selects the inverter to be used. In the "MAIN" ("NORMAL") position the left hand inverter is operating, and in the "SPARE" ("ALTERNATE") position the right hand inverter is on.

On late series airplanes a changeover relay automatically switches from the main inverter to the spare when the main fails. As soon as this automatic change occurs a light on the pilot's control panel next to the inverter switch lights up.

Function of the Voltage Regulator

The engine generator, mounted in back of each engine, is geared to turn three times while the engine turns twice. The variable rpm of the engine would tend to vary the generator output were it not for the voltage regulator in the accessory section of the airplane.

The regulator operates by a variable resistance which changes the strength of the field magnets of the generator. The variable resistance is affected by an electromagnet which operates against spring tension. Voltage setting of the generator is set by varying the spring tension of the regulator or by varying the amount of current allowed to flow into the electromagnet, depending on the particular type of regulator used. Voltage regulators are in a

shield under the pilot's floor in catwalk leading to bombardier's compartment.

Once the regulators are adjusted they should not be touched by the flight crew unless the generators are greatly unbalanced. Some unbalance is to be expected at low loads, but no one generator should be operating at more than its rated 200 amperes. If one is, turn it off and see if the remaining generators can divide the load without one of them exceeding 200 amperes. Only if one of the generators still exceeds its rating should the regulators be adjusted in flight.

Report consistent unbalance of generators on Form 1A.

Reverse Current Relay

A reverse current relay in each nacelle connects the positive lead of the generator to the power circuit bus in the back of the nacelle. This relay is usually set at 26½ volts. It cannot close unless the generator switch is closed, and it should automatically open whenever the current flow reverses (battery to generator).

Checking and Adjusting Generator Systems

Whenever starting engines, check the generators individually. After warming engines at 1000 to 1200 rpm, run up each engine slowly for check. Before running up an engine, turn on that particular generator. The pointer on the voltmeter will be somewhere in the center of the dial. The ammeter should not register, as voltage is too low to close the relay. As engine rpm is increased voltage increases. Between 26 and 27 volts, the ammeter should suddenly indicate amperage, showing that the relay has closed. Voltmeter should reach its maximum reading well below 1800 rpm. Turn off generator and repeat check with each of the other generators. **Only during checks should the generators be turned on individually.**

Equalizer Coils

Under ordinary conditions generators should be set to give a 28-volt reading on an accurate voltmeter. Sometimes voltage may vary one-half volt higher or lower. As long as all 4 generators maintain exactly the same voltage, amperage loads will be equal and the system is considered equalized or paralleled. A special equalizer coil is incorporated in the electromagnet of the voltage regulator and is interconnected with the equalizer coils of the other regulators. These coils help to maintain equal voltage and amperage of the 4 generators.

If in flight the ammeters show too great a disagreement, a paralleling adjustment is necessary. If one ammeter reads higher than the others, the reason is that the voltage is higher on that generator. An adjustment of the voltage regulator by the flight engineer will correct this condition. The total output of the 4 generators remains the same; therefore, if the amperage of one is increased, the amperage of the other will be decreased.

When equalizing the generators it is advisable to synchronize the propellers and fly straight and level at a moderate cruising rpm—preferably about 1850 rpm. Leave all generators on, of course; otherwise current cannot flow from generators. Turn off batteries and all possible electrical equipment. The inverter alone will use enough current to cause all the ammeters to give a reading.

The less adjustment you make, the better. Careless adjustment may alter the voltage from the desired 28 volts. If ammeters read within 3 amperes with only inverter on, they will be within 20 amperes of each other at normal load.

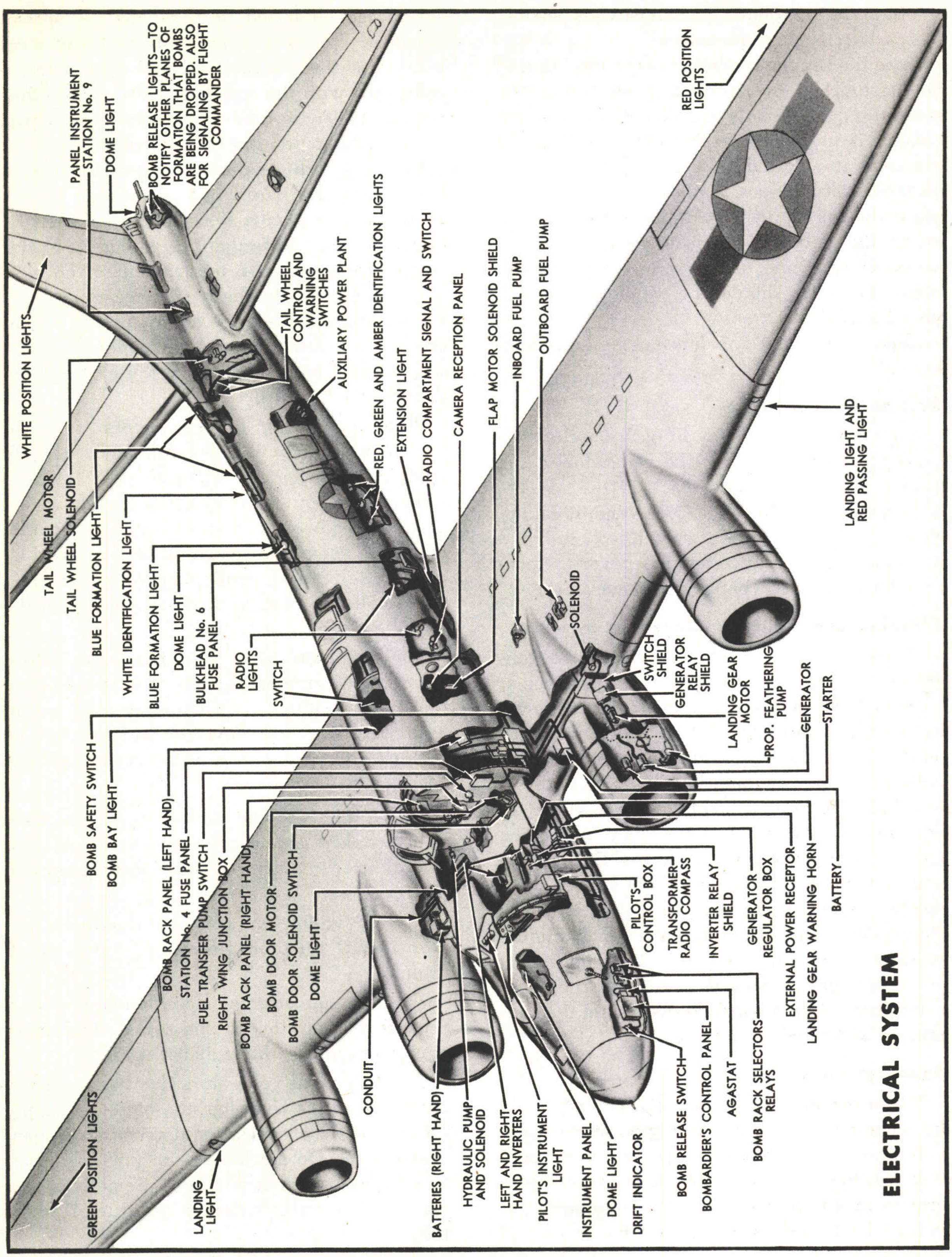
Remember:

(1) Voltmeters and ammeters of the B-17 indicate only generator performance. If generators are not turning, these instruments do not function.

(2) The voltmeter reads any time the generator turns, whether generator switch is off or on.

(3) The ammeter indicates amount of current the generator is supplying. The more equipment in use, the higher it reads.

(4) As long as generators function properly, batteries will be charging; the batteries supply no current to electrical equipment while generator is on. Do not hesitate to turn off a battery if you believe it advisable. Sometimes you can save a boiling battery if you turn it off in time.



ELECTRICAL SYSTEM

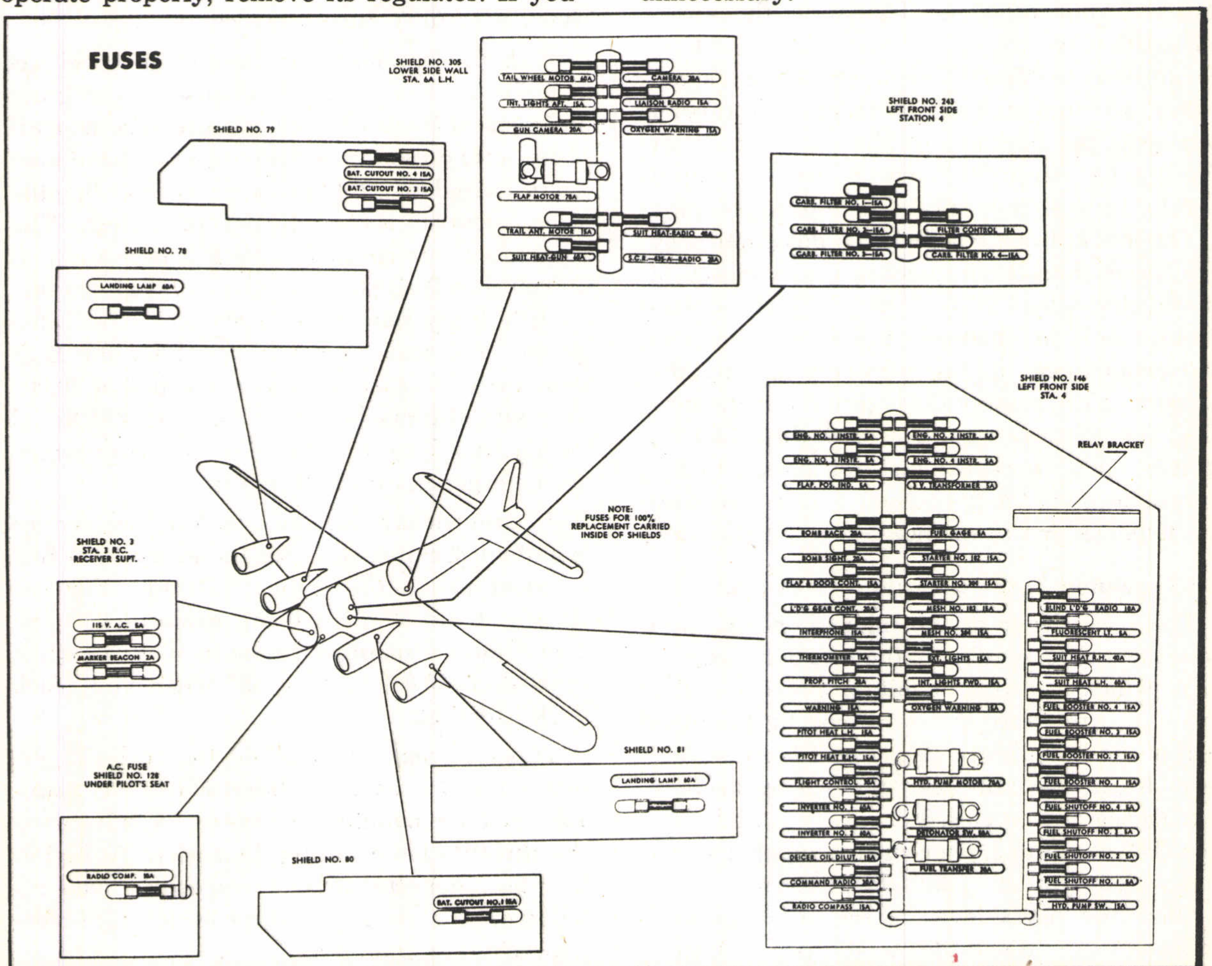
(5) Avoid turning off a good generator in the air, except perhaps momentarily to check another one. When a generator is left running and not putting out current, its commutator is apt to glaze and be inefficient. Also, the relay has a tendency to chatter, and its points may burn when this happens.

(6) The purpose of the equalizing coil is to help equalize generator loads **only** when slight voltage variation causes unequal ammeter readings. If one generator is left off and the others are on and producing much current, too much load may be placed on the equalizer coil and the regulator may be damaged. Either have all **properly functioning** generators on or all off (except when checking).

(7) A bad generator is never completely disconnected from the electrical system until the regulator is removed. If a generator will not operate properly, remove its regulator. If you are flying, keep that switch off. If on the ground, remove the generator cannon plug also, to prevent wiring damage, and tape off the cockpit switch. In the B-17 the loss of a generator is not serious. More than twice as much power is available than will be needed. If a bad generator is properly disconnected the rest of the system will not suffer.

(8) Do not ask engineer to parallel generators when engines are operating at less than 1800 rpm. Don't try to parallel them on takeoff; wait until you have leveled off. Set voltage with all generator switches off. Do all your minor amperage paralleling with all switches on and little load on the system.

(9) The pilot **must** know location and disposition of fuses in fuse panels. Replacement of burned-out fuses often makes emergency action unnecessary.



Turbo-superchargers

Each engine on the B-17 has a turbo-supercharger which boosts manifold pressure for takeoff and provides sea-level air pressure at high altitudes. It does this by compressing the air before it enters the intake manifold.

Engine exhaust gas furnishes the power for operating the turbo-supercharger. The exhaust gas passes through the collector ring and tailstack to the nozzle box and then expands to atmospheric pressure through the turbine nozzle, driving the bucket wheel at high speed. The bucket wheel in turn drives the impeller, or compressor.

A ram air inlet duct from the leading edge of the wing supplies air to the impeller. As the air is compressed, its temperature increases, and in order to avoid detonation the air is passed through the intercooler, where the temperature is reduced. The internal engine impeller, driven by the engine crankshaft, further increases the pressure of the air as it enters the intake manifold. Greater power output results from higher intake manifold pressure.

The amount of turbo boost is determined by the speed of the turbo bucket wheel. Speed of the bucket wheel is determined by the difference in pressure between the atmosphere and the exhaust gas in the tailstack, and by the amount of gas passing through the turbine nozzles. The waste gate controls both these factors. If it is open, more exhaust gas passes to the atmosphere via the waste pipe and less reaches the tailstack or turbine nozzles.

Oil-Regulated Turbo-supercharger Control

The boost lever at the pilot's control stand sets the turbo regulator (operated by engine oil), which controls manifold pressure. The amount of pressure is determined by the position of the boost lever. High boost lever setting provides higher tailstack pressure by keeping the wastegate in a closed or nearly closed position. The resulting higher bucket-impeller speed gives higher intake manifold pressure.

Once the boost lever is set, the regulator automatically adjusts the waste gate as necessary to maintain a constant tailstack pressure, regardless of altitude.

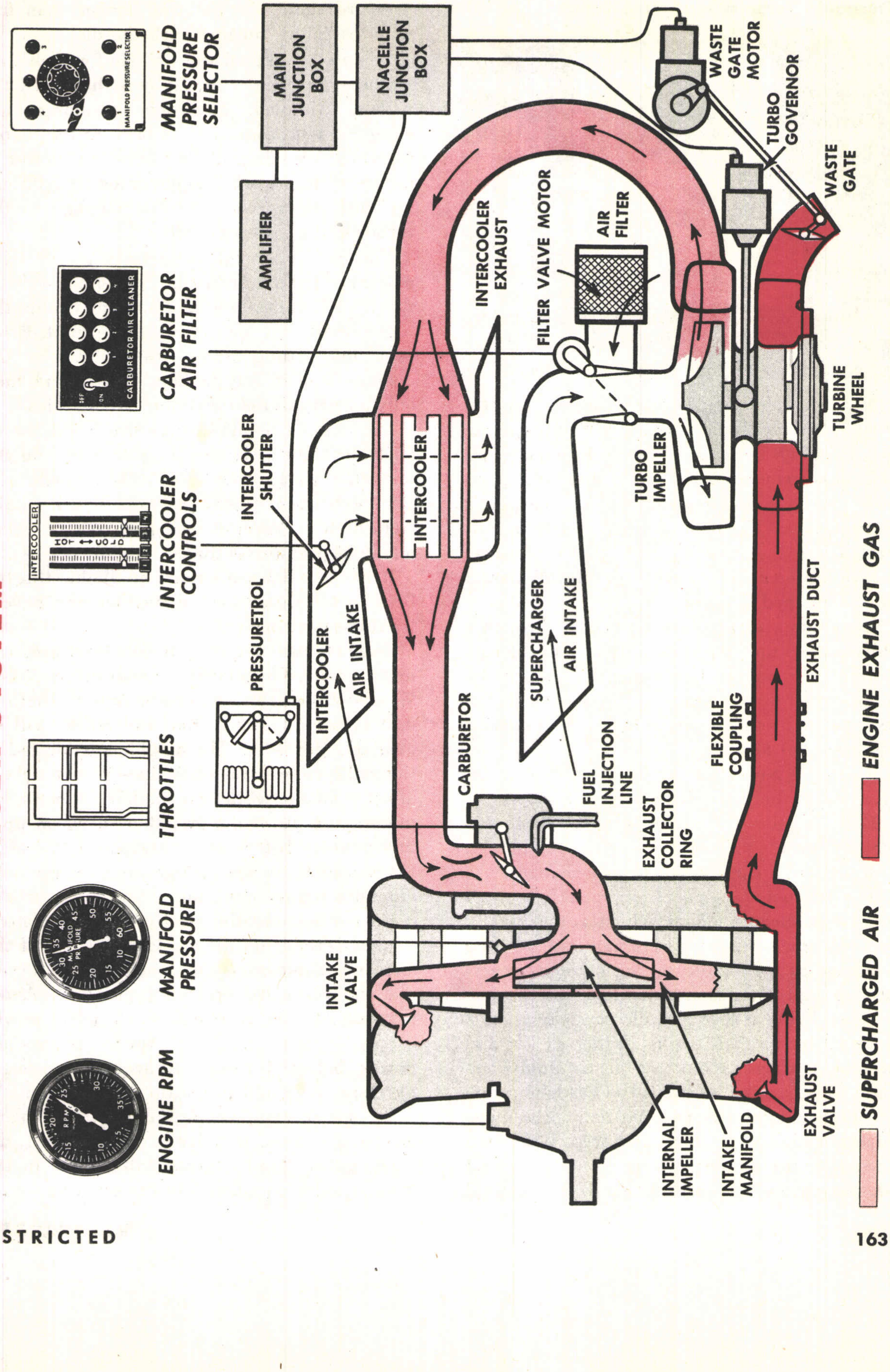
Remember that the oil-operated turbo regulator does not provide constant intake manifold pressure during a climb; it simply provides constant tailstack pressure. At the start of the climb, manifold pressure is set to the desired value with the control levers. Atmospheric pressure decreases rapidly during the climb. The difference between tailstack pressure and atmospheric pressure thus increases with altitude and results in a greater pressure differential across the bucket wheel, increasing its rpm. This drives the impeller faster, increasing manifold pressure. This is why you must keep pulling the turbo control levers back (reducing tailstack pressure) during the climb.

At high altitude, the turbo bucket wheel has a tendency to overspeed because of the great differential between tailstack pressure and atmospheric pressure, even though you have kept your desired manifold pressure by retarding the turbo control levers during the climb. The maximum safe speed for the B-2 type turbo is 21,000 rpm. This speed is reached at 27,000 feet with Military power, at 30,000 feet with Rated power. The maximum safe speed for the B-22 type turbo is 24,000 rpm. It is reached at 30,000 feet with Military power; at 34,000 feet at Rated power. A 5% overspeed allowance is provided for emergencies for both types.

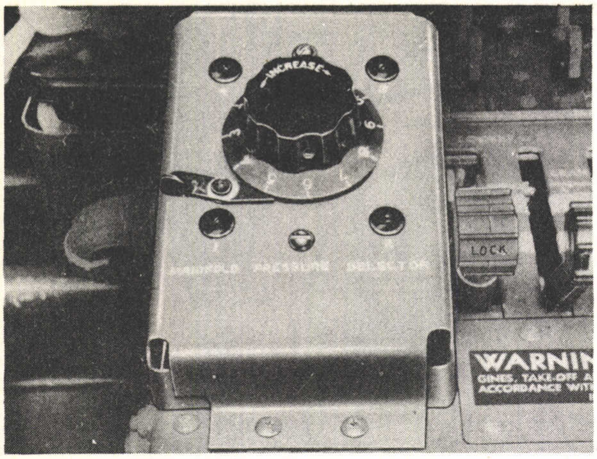
To prevent turbos from overspeeding, reduce manifold pressure 1.5″ Hg for every 1000 feet climbed above the critical altitude. For example, if the climb is being made at 38″ and 2300, reduce manifold pressure to 36.5″ when you reach 30,000 feet, to 35″ when you reach 31,000 feet, etc.

To save wear and tear on the turbo-supercharger and to avoid carburetor trouble, **maintain desired manifold pressure by advancing the throttles before using the turbos.** At higher altitudes, definite turbo overspeeding may result from the use of part throttle and full turbo-supercharger operation.

TURBO-SUPERCHARGER SYSTEM



Electronic Turbo-supercharger Control



The electronic turbo-supercharger control system in late B-17's consists of four separate regulator systems, one for each engine, all simultaneously adjusted by a **manifold pressure** (turbo boost) **selector dial** on the pilot's control panel. The turbo control system is calibrated on the ground, and **the calibrating screws on the manifold pressure selector should not be touched in flight.**

Induction pressures are controlled through a Pressuretrol unit connected directly to the carburetor air intake. Consequently, unlike the oil-operated turbo regulator, the electronic control system provides constant manifold pressure regardless of altitude.

Electrical power for the entire system is derived from the 115-volt, 400-cycle inverter.

Each regulator includes a turbo governor which prevents turbo overspeeding both at high altitude and during rapid throttle changes.

The exhaust waste gate is operated by a small reversible electric motor which automatically receives power from the regulator system when a change in waste gate setting becomes necessary to maintain desired manifold pressure.

When flying at high altitude you may reach a point where further turning of the selector dial fails to produce an increase in manifold pressure. This means that the turbo has been overspeeding and the overspeed portion of the turbo governor is now limiting turbo rpm. When you encounter this condition, turn the selector dial counter-clockwise until it controls manifold pressure again. Do not wait longer than five minutes before turning back the dial.

Be sure to take off the 1.5" Hg for each 1000 feet above critical altitude by dialing back the turbos. Although electronic regulators are equipped with governors to prevent the turbos from overspeeding, dialing back the power is necessary to prevent the governor from "hunting" and to prevent possible damage to the turbos if the governor fails.

You can obtain full emergency power (war power) at maximum engine rpm and full throttles by releasing the dial stop and turning the turbo boost selector dial up to its limit. However, this setting places heavy strain on the engines. **Use it only in emergencies and then only for periods not exceeding five minutes.**

If excessive manifold pressure is developed on takeoff and it is necessary to complete the takeoff, throttle back to 40" Hg immediately. This prevents excessive leanness, which results from high carburetor deck pressure at higher manifold pressure settings.

If excessive boost occurs in flight, throttle back to 40" Hg as soon as possible and have a trouble-search made.

Either a rise or a drop in manifold pressure may be caused by a faulty tube in the amplifier. Whenever possible, replace a faulty amplifier unit before landing so that full power will be available if needed. The amplifier is located in the radio compartment. Reduce power on the affected engine while the amplifier is being replaced, and allow the amplifier to warm up a few minutes before resuming power. Be alert for manifold pressure change when the replaced amplifier begins operating.

Remember that the electronic turbo control system depends on the electrical system of the airplane. Make sure the generators, batteries, and inverters are operating properly. Avoid shutting off the inverters or electrical power supply. If either has to be turned off, reduce power before turning on again, to prevent excessive manifold pressure.

In case of complete failure of the airplane electrical system, or failure of the inverter, the waste gates on all engines will remain in the same position as when failure occurred.

HEATING AND VENTILATING SYSTEM

Your B-17 has either one of two types of exhaust heating systems: a hot air system in later airplanes, a glycol system in earlier ones.

Hot Air System

In the hot air system, outside air, brought in through scoops, passes over heat exchangers in the exhaust systems in No. 2 and No. 3 nacelles. This heated air then goes to individually controlled flapper valves, which either divert it overboard or send it to a second heat exchanger (similar to a radiator), after which it is vented overboard.

Air for the cabin is brought in from each inboard carburetor air scoop and ducted to valves interconnected with the hot air valves.

Control handles in the radio room, one for the No. 2 nacelle heating system and one for the No. 3, control both the cold air and hot air valves. These control handles have three positions: "HOT," "COLD," and "OFF."

When the control for one of the systems is placed in "HOT" position, the heated air passes through both heat exchangers and is vented outside. The air for the cabin passes through the secondary heat exchanger, is heated, and then goes into the cabin ducting.

When the control is in the "COLD" position, the heated air is vented overboard and does not go into the secondary heat exchanger. Air for the cabin still passes through the cabin ducting and provides cool, fresh air for ventilation. The control can be placed in any position between "HOT" and "COLD," thus governing the amount of heat supplied to the interior of the airplane.

When the control is "OFF" both cold and hot air valves are closed, and no air comes into the cabin ducting.

Heating outlets are provided in all compartments, and there are defrosters for nose, bombsight window, astrodome, windshields, waist and tail gun windows. Individual control of all important outlets is possible. However, it is usually better to control temperature by positioning the master controls in the radio room at the desired setting between "COLD" and "HOT" than by adjusting the individual controls.

An important improvement over the glycol system is that heater control handles do not have to be in the "OFF" position for ground operation. Control handles may be left in any of the three positions.

Glycol System

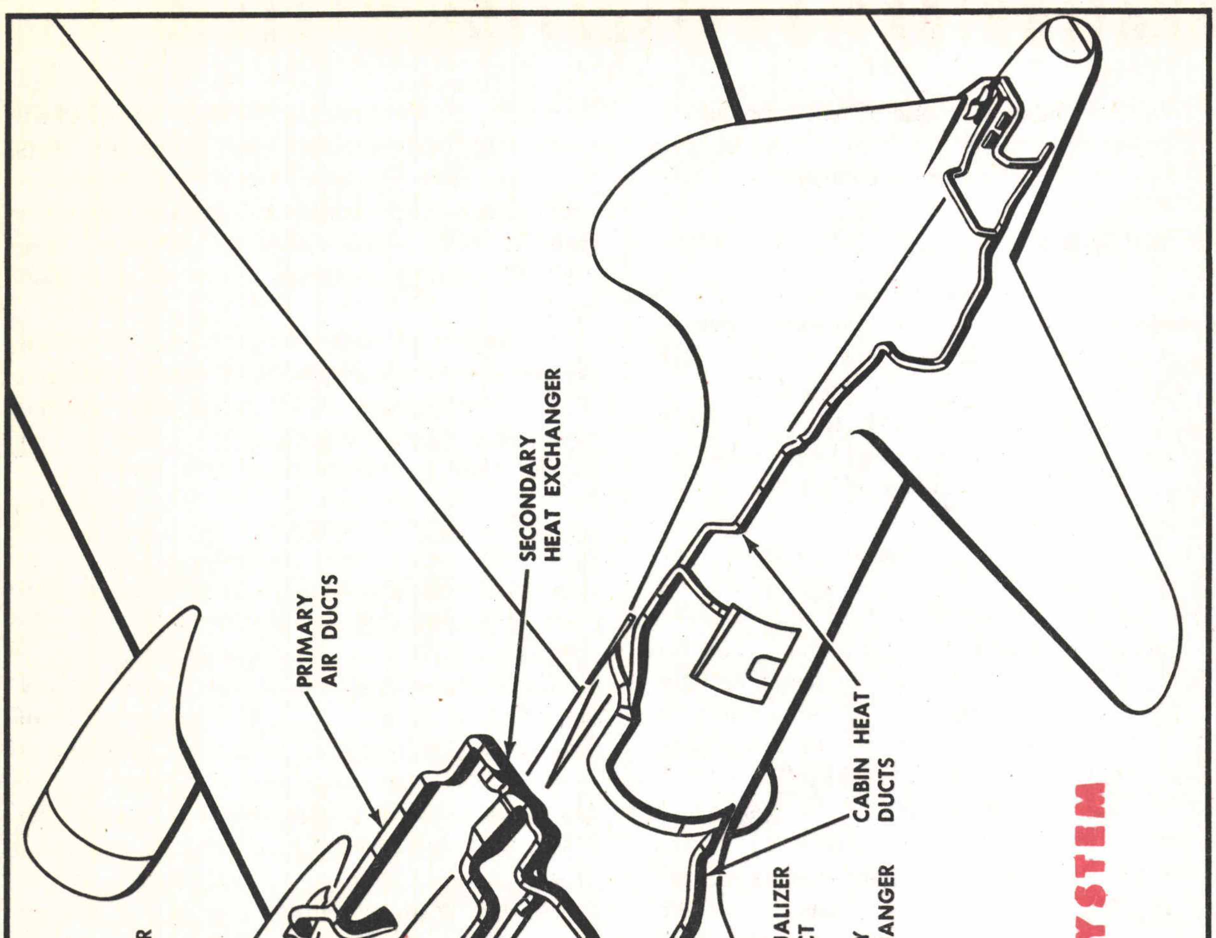
The second type of heating system supplies cabin heat through a glycol system in nacelle No. 2.

The heating system fluid (glycol solution of 55% diethylene glycol and 45% ethylene glycol by weight) is stored in a tank in the top of nacelle No. 2. The glycol flows from the tank to the engine-driven pump, which circulates the fluid at a rate of 55 to 60 U.S. gallons per hour. The flow is directed to a filter which removes impurities from the fluid. The glycol is then pumped through 3 heaters, which are installed in series and located in the exhaust stack, where it collects the heat of the exhaust gases.

A relief valve, between pump and filter, bypasses the glycol back to the supply line if high pressure is built up in the system during cold weather, or if the heaters are clogged.

The circulation of the glycol is continuous and therefore it must be constantly cooled. For this purpose there is a radiator between the spars in the left-hand wing gap. Ram air from the intercooler air inlet absorbs heat from the glycol at the radiator, and passes through the radiator and into the cabin. The cooled glycol passes into the supply tank. A controllable damper in the radiator may be operated to spill the air overboard if desired.

See next page for diagram of Heating System



HOT AIR HEATING SYSTEM

COMMUNICATION EQUIPMENT

The B-17 contains equipment for long and short-range two-way voice and code communication, intercommunication between crew members, emergency transmission, directional indication, and reception of marker beacon signals.

Interphone

The interphone system provides for communication between crew members. Command radio and radio compass signals are audible over the interphone system at all crew stations. Any crew station can talk over the command transmitters.

Interphone equipment includes a dynamotor and amplifier located under the radio operator's table, and 12 jackboxes located throughout the airplane; 3 in the nose (for the navigator, bombardier, and forward gunner), 3 on the flight deck (for the pilot, copilot, and top turret gunner), 2 in the radio compartment, 3 in the waist compartment, and one in the tail compartment.

Remember: Crew members should wear headsets at all times during flight.

Interphone Call

The "CALL" position on the jackbox enables the user to over-ride reception on all other jackbox stations for the purpose of calling any particular station. A spring returns the selector switch to "INTER" so that it cannot be left in the "CALL" position inadvertently. For obvious reasons, use of the "CALL" position should be held to a minimum.

Command Radio

The command radio is for short-range communication with aircraft and ground stations.

Voice transmission over the command set is available to all crew stations, but code transmission is limited to the pilot and copilot, who alone have a transmitting key. It is on the remote control box on the ceiling of the pilot's compartment.

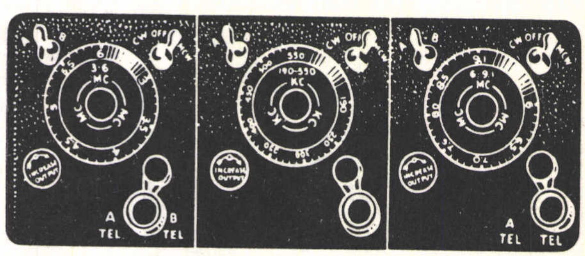
The command radio consists of 3 receivers and 2 transmitters on the right forward bulkhead of the radio compartment. Remote controls are on ceiling of pilot's compartment.

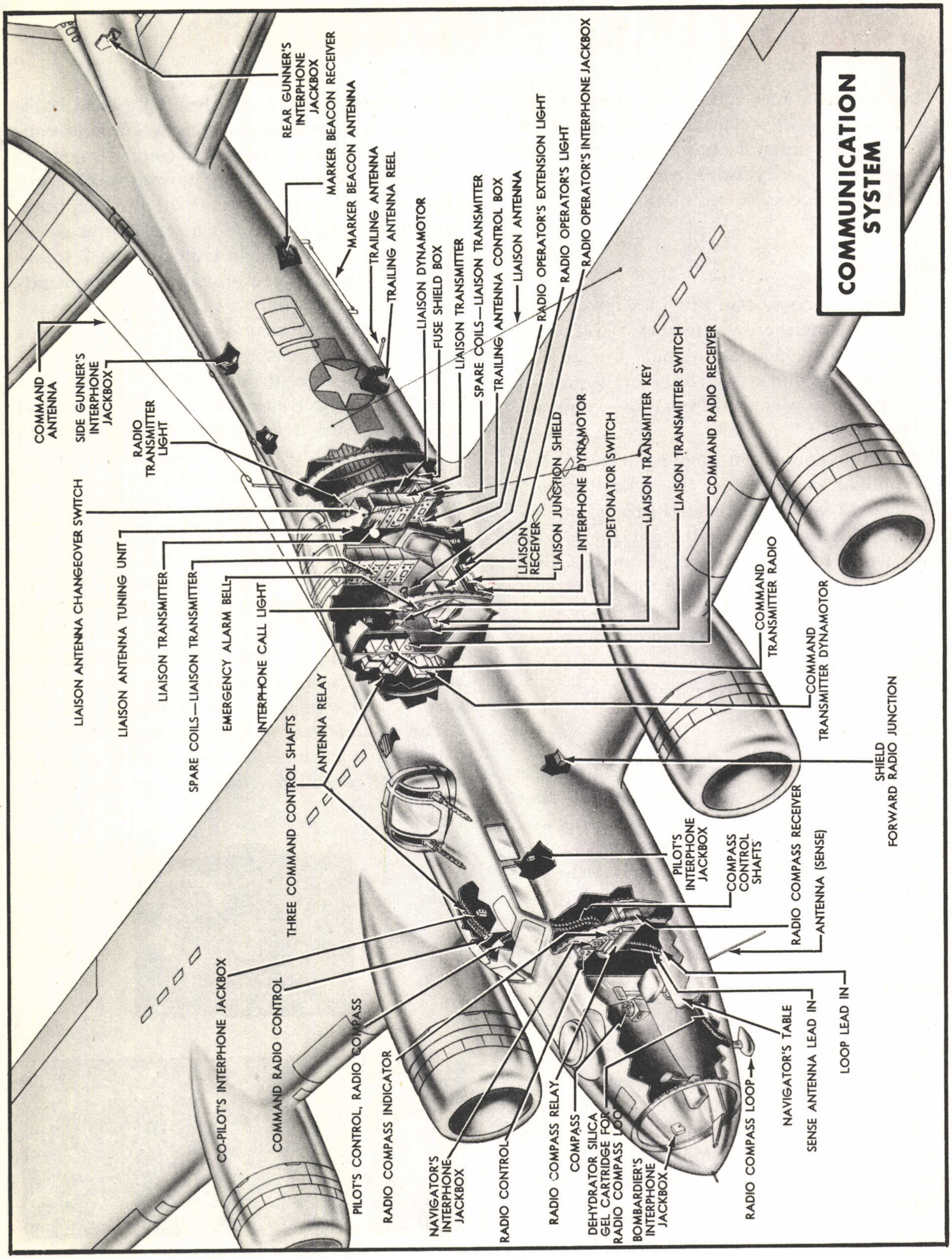
Remote Control Units: The transmitter control box has an on-off toggle switch which turns on either transmitter, and a transmitter selector switch which selects either of the 2 transmitters. (Positions are provided for 4 transmitters, should the 2 extras be installed.) A wave selector switch turns on voice, CW (continuous wave) or tone as desired.

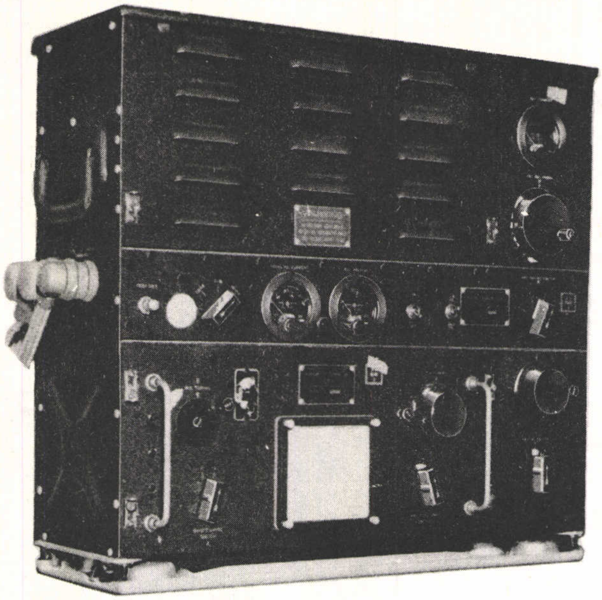
The receiver control is divided into 3 control units, one for each receiver. The low band receiver covers 190-550 Kc, the intermediate band from 3000 to 6000 Kc, and the high band from 6000-9100 Kc. Each receiver control unit has 2 switches to operate it.

The A-B switch selects either jackbox or control unit. Use "A" if plugged into jackbox; use "B" if plugged directly into control unit. **A tone selector switch** which can select "TONE," "CW," or "MCW" should be turned to modulated CW with "A" and "MCW" on. Then you can tune to desired frequency by means of a small handle which turns a calibrated dial.

The reliable transmitting range of the command set is 25 miles or less. Under good atmospheric conditions greater range may be obtained.




COMMUNICATION SYSTEM
REAR GUNNER'S INTERPHONE JACKBOX
MARKER BEACON RECEIVER
MARKER BEACON ANTENNA
TRAILING ANTENNA
TRAILING ANTENNA REEL
LIAISON DYNAMOTOR
FUSE SHIELD BOX
LIAISON TRANSMITTER
SPARE COILS—LIAISON TRANSMITTER
TRAILING ANTENNA CONTROL BOX
LIAISON ANTENNA
RADIO OPERATOR'S EXTENSION LIGHT
RADIO OPERATOR'S LIGHT
RADIO OPERATOR'S INTERPHONE JACKBOX
COMMAND ANTENNA
SIDE GUNNER'S INTERPHONE JACKBOX
RADIO TRANSMITTER LIGHT
LIAISON ANTENNA CHANGEOVER SWITCH
LIAISON ANTENNA TUNING UNIT
LIAISON TRANSMITTER
SPARE COILS—LIAISON TRANSMITTER
EMERGENCY ALARM BELL
INTERPHONE CALL LIGHT
LIAISON RECEIVER
LIAISON JUNCTION SHIELD
INTERPHONE DYNAMOTOR
DETONATOR SWITCH
LIAISON TRANSMITTER KEY
LIAISON TRANSMITTER SWITCH
COMMAND RADIO RECEIVER
COMMAND TRANSMITTER RADIO
COMMAND TRANSMITTER DYNAMOTOR
ANTENNA RELAY
THREE COMMAND CONTROL SHAFTS
SHIELD FORWARD RADIO JUNCTION
PILOT'S INTERPHONE JACKBOX
COMPASS CONTROL SHAFTS
RADIO COMPASS RECEIVER
ANTENNA (SENSE)
LOOP LEAD IN
SENSE ANTENNA LEAD IN
NAVIGATOR'S TABLE
RADIO COMPASS LOOP
CO-PILOT'S INTERPHONE JACKBOX
COMMAND RADIO CONTROL
PILOT'S CONTROL, RADIO COMPASS
RADIO COMPASS INDICATOR
NAVIGATOR'S INTERPHONE JACKBOX
RADIO CONTROL
RADIO COMPASS RELAY
COMPASS
DEHYDRATOR SILICA GEL CARTRIDGE FOR RADIO COMPASS LOO
BOMBARDIER'S INTERPHONE JACKBOX



LIAISON TRANSMITTER

This transmitter, on the aft bulkhead of the radio compartment, insures communication with aircraft in flight and ground stations over distances up to 3000 miles, depending on atmospheric conditions and method of transmission. The usual reliable distances are 250 miles on voice, 500 miles on tone and 750 miles on CW. Only one jackbox position (radio operator) can transmit on the liaison set.

This set has 7 interchangeable tuning units covering frequencies from 360-650 Kc and 1500-12,500 Kc, and including a low band from 200-500 Kc in some models. For tuning this set, see communication section of B-17 T. O.'s.

The liaison receiver on the radio operator's table covers a frequency range from 1500-18,000 Kc. It uses the same antenna as the transmitter. This is connected to a throw switch on the left side wall. This switch can change over to the trailing antenna (also on left side wall). The trailing antenna is operated from a control box to the right of the change-over switch.

RADIO COMPASS (SCR 269-G)

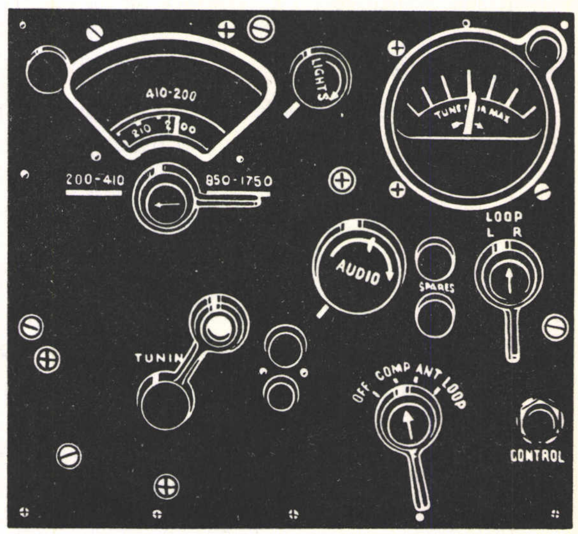
The radio compass is a multi-purpose receiver designed primarily as a navigational instrument.

The power for this set comes from the airplane's batteries and inverters. The various relays and switches operate on the direct current supply, and the receiver and motors for rotation of the loop operate on the inverters.

This set has 2 antennas: a sensing (whip), or non-directional antenna, and a loop, or directional antenna.

The radio compass is a multi-band receiver and, as installed in B-17 aircraft, may be remotely controlled from either of 2 identical control boxes. One of these boxes is above and between the pilot and copilot; the other directly above and slightly to the left of the receiver itself in the navigator's compartment.

Each of the control boxes (BC-434-A) has (1) an antenna selector switch; (2) a band-change switch; (3) a control button; (4) a main tuning control; (5) a tuning indicator (meter); (6) an audio output control; (7) a loop L-R switch; (8) a control light; (9) a dial light, and (10) a dial light control.



Antenna Selector Switch

This four-position ("OFF - COMP - ANT - LOOP") switch selects the type antenna or antennas to be used, AVC or MVC, and largely determines the indication and action of the loop. The 4 positions of this switch may be explained as follows:

"OFF": Self-explanatory.

"COMP": When in this position, the set is using both sensing (whip) and loop antennas. Automatic volume control is always present in this position, and the operation of the radio compass indicators and loop is automatic.

"ANT": This position utilizes only the whip or non-directional antenna; therefore the loop and indicators do not operate. Manual volume control is now present, and the volume is adjusted or regulated only by means of the audio control. This position should be used at all times for the initial tune-in of the station.

"LOOP": Now only the loop or directional antenna is in use. The operation of the loop and indicators are controlled by means of the Loop L-R switch. Again you have only manual volume control.

Band-change Switch

This electrically controlled switch selects the band or range of frequencies desired. There are 3 positions, or bands. One band covers frequencies from 200 to 410 Kc; another from 410 to 850 Kc; the third from 850 to 1750 Kc.

Tuning Control

After selecting the desired band with the band change switch, use this control to select any desired frequency within this band.

Control Light

This light on the control box indicates the control box actually controlling the compass receiver. When the light is on, the control box is in control of the radio compass.

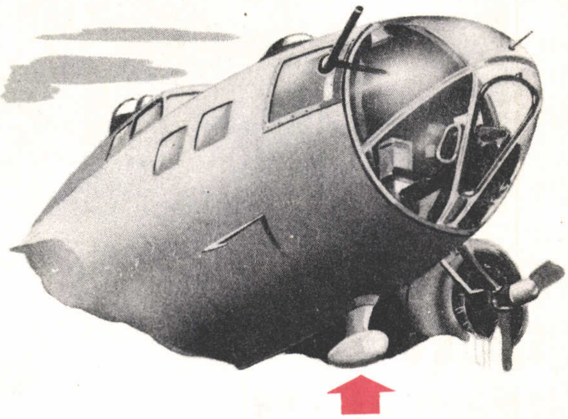
Control Button

This push button throws control of the radio compass from one control box to the other. If the light on the desired control box is unlighted, press this control. When you release it, control is switched from the other control box to the desired box.

Audio

By varying this control, the operator may adjust the headset volume as desired.

Loop L-R



This switch controls rotation of the loop when the antenna switch is in "LOOP" position. The loop can be rotated at two different speeds. When the Loop L-R switch is pressed in and switched to the desired position (L rotates loop to left, R to right) and held there, the loop rotates at a fairly rapid speed. When the switch is not pushed in, but only held in the desired position, the loop rotates slowly. When the loop is rotated by this switch the compass indicators rotate to show the position of the loop.

Tune for Maximum Indication

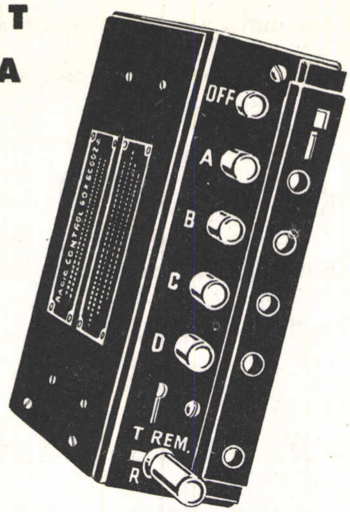
When tuning in any station, the main tuning control should be tuned for maximum swing of the needle on "Tune for Maximum" indicator.

Dial Light Control

This control regulates the brilliance of the dial light.

For instructions on how to use the radio compass, see **Advanced Instrument Flying, T.O.–30-100.**

RADIO SET SCR 522 A



The SCR 522 A VHF (very high frequency) transmitter-receiver radio set provides 2-way radio-telephone communication between aircraft in flight and between aircraft and ground stations. Provision is made for voice communication and continuous audio-tone modulation.

The pilot and co-pilot control the SCR 522 by means of the radio control box on the left side of the pilot's control pedestal in the B-17. The set operates on any one of 4 pre-set crystal-controlled frequency channels lying within the range of 100-156 Mc. Line-of-sight communication is normally necessary for satisfactory operation of the radio set.

The following table lists the approximate range to be expected, assuming communication is taking place between the aircraft and a ground station over level country.

Altitude above ground	Approximate range
1000 feet	30 miles
3000	70
5000	80
10,000	120
15,000	150
20,000	180

Radio Control Box

The radio control box to the left of the pilot's control pedestal provides the only complete remote control of communications functions. Five red push buttons are the means by which any one of the 4 channels (A, B, C, and D) is selected and the power turned off. When the "OFF" push button is pressed, the dynamotor is stopped. The push buttons are interconnected so that not more than one channel can be selected at a given time. A light opposite each push button indicates which channel is being used.

The "T-R-REM" switch (transmit-receive-remote) is normally in the "REM" position, permitting press-to-talk operation by means of the conventional push button microphone switch on the pilot's control wheel, which when depressed switches the equipment from **receive** to **transmit.** In the "T" position the transmitter is in continuous operation. In the "R" position the receiver is in continuous operation.

The lever tab, directly above the "T-R-REM" switch, when lowered, blocks the switch from "REM" position and spring-loads the switch lever so that unless it is held in the "T" position it will return to "R."

The small lever tab opposite the "OFF" push button is a dimmer mask to reduce the lamp glare. The lamp opposite the "T-R-REM" switch is on when receiving and off when transmitting.

Transmitter-Receiver Assembly

The transmitter and receiver units are in a single case. The transmitter employs a crystal-controlled oscillator circuit and operates in the frequency range of 100-156 Mc on one of the 4 pre-set channels A, B, C, and D. Average output power of the transmitter is 8 to 9 watts, using a total power input current of 11.5 amps at 28 volts.

The receiver is a sensitive superheterodyne unit employing a heterodyne oscillator whose frequency is controlled by any one of 4 quartz crystals. Thus the 4 crystal-controlled channel frequencies within the range 100-156 Mc are available for instantaneous selection at the re-

mote control position. For reception the total input current is 11.1 amps at 28 volts.

Dynamotor Unit

The dynamotor operates on the 28-volt power circuit and supplies 3 regulated voltage sources (300-volt DC, 150-volt DC, and 13-volt DC) required for operation of the transmitter-receiver assembly.

In addition to the equipment listed above, jackboxes, junction boxes, headsets, and microphones are used with the radio set.

Operation of the SCR 522 A

The "T" and "R" positions on the control box permit transmission and reception without the use of the press-to-talk button. However, most airplanes are modified to eliminate the "T" and "R" positions or have the control safetied in the "REM" position. It is advisable to use the "REM" position at all times.

To Operate:

See that the switch is in the "REM" position (if not safetied there).

Select a channel by pressing push button A, B, C, or D.

To receive: Under these conditions the receiver is normally in continuous operation.

To transmit: Depress the press-to-talk button and speak into the microphone.

To receive again: Release the press-to-talk microphone button.

To shut off the equipment, press the "OFF" button.

Common Uses of Channels

"A" channel is usually used for all normal plane-to-plane communication or for plane-to-ground communication with a Controller.

"B" channel is common to all VHF-equipped control towers. It is normally used to contact the control tower for takeoff and landing instructions.

"C" channel is frequently used in contacting homing station.

"D" channel is normally used for plane-to-ground contact with D/F stations, and as a special frequency which is automatically selected at regular intervals by the action of a contactor unit.

Precautions During Operation

Avoid prolonged use of the radio on the ground to conserve the batteries and avoid overheating of the dynamotor.

If the transmitter and receiver fail to operate when a channel push button is pressed on the radio control box, press another channel push button, then again press the push button for the desired channel. Transmission and reception should now be possible.

FREQUENCY METER

A frequency meter is standard equipment on all B-17's and should be kept in the radio compartment. It is used to check and correct transmitters and receivers on frequency ranges from 125 Kc to 20,000 Kc. For use and operation, see Technical Orders.

MARKER BEACON RECEIVER

The radio marker beacon receiver receives ultra-high frequency signals used in aircraft navigation and landing, and reproduces them visually by an amber light on the pilot's instrument panel. When the receiver is over a keyed transmitter, such as a C.A.A. marker, or certain types of Army transmitters, the indicator lamp flashes in accordance with the identifying signal of the transmitter.

STATIC DISCHARGERS

Static discharges consisting of glycol or glycerine soaked wicks in hollow tubes are attached to the tips of the wings and stabilizers. The wicks provide means for the static electricity accumulated in flying through electrically charged areas to be dissipated without creating radio interference.

EMERGENCY OPERATION OF RADIO EQUIPMENT

Interphone Equipment Failure

If the interphone equipment fails, the audio frequency section of the command transmitter may be substituted for the regular interphone amplifier. To make this connection, the pilot places his command transmitter control box channel selector switch in either channel No. 3 or 4 position (or whatever position is not being used with a transmitter). Set the interphone jackbox selector switch to "COMMAND" to place the interphone equipment in operation.

When the command transmitter control box channel selector switch is set in either the No. 3 or 4 position for emergency operation of the interphone equipment, it is not possible to establish communication with any ground station or any other airplane. It is possible at all times to resume normal command set operation by placing the channel selector switch of the command transmitter control box in either the No. 1 or 2 position.

Substitution of Radio Compass Receiver for Low-Frequency Command Set Receiver

If the low-frequency receiver of the command set fails, the radio compass receiver may be substituted, with the pilot having **direct control** over the compass receiver. To complete this emergency hookup, the pilot must set his interphone jackbox selector switch in the "COMP" position and then place the radio compass selector switch in the "ANT" position. The radio compass can then be tuned as desired.

Substitution of Liaison Receiver for Low, Medium, and/or High-Frequency Command Receiver

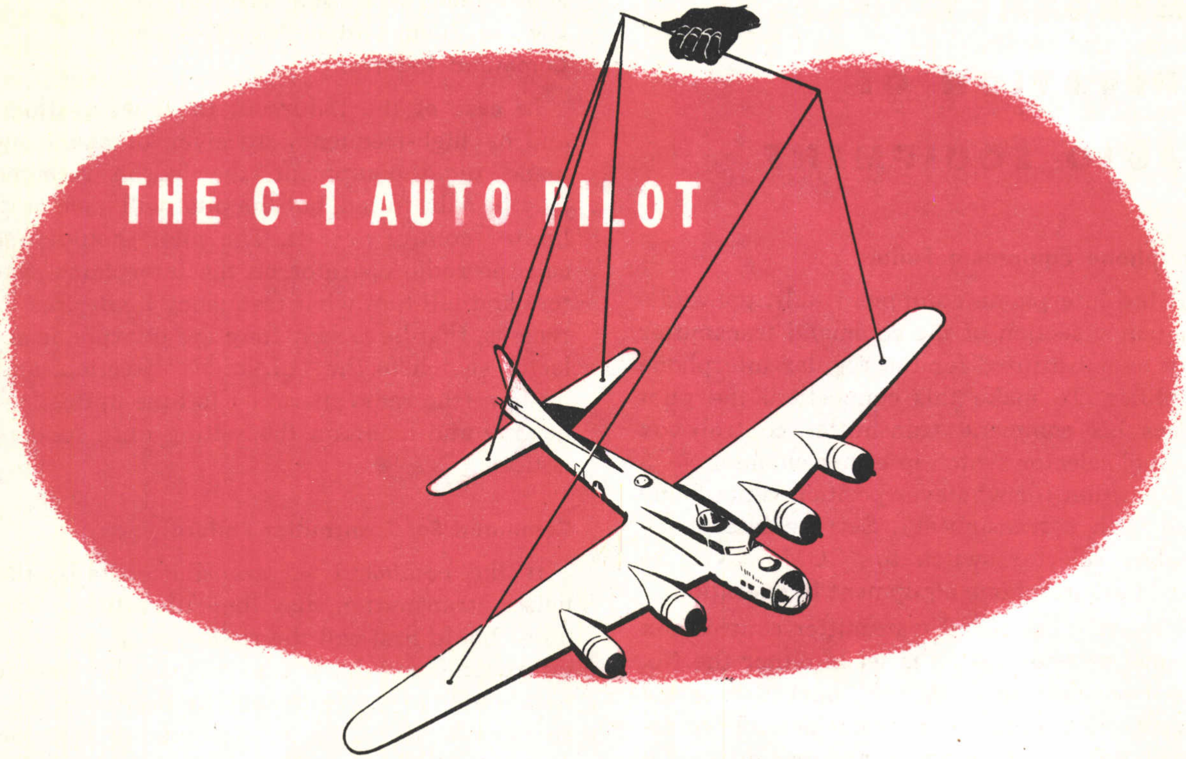
In case of the failure of the low, medium, and/or high-frequency receiver of the command radio equipment, the liaison receiver may be substituted, but the pilot will have only limited control over it. The pilot should first call the radio operator on the interphone system and tell him what frequency he desires to receive, that he is switching the interphone selector switch to the "LIAISON" position, and for him (the radio operator) to tune in this frequency and maintain the setting until further notice.

Command Set Transmitter Failure

If the command set transmitter fails, the liaison transmitter may be substituted. The pilot should first call the radio operator on the interphone and have him adjust the liaison transmitter to the frequency he desires to use. He should then set his interphone selector switch to the "LIAISON" position and operate his microphone button in the same manner that he did when the command set was in operation. When he is through using the liaison transmitter, the pilot should place the interphone selector switch in the "INTER" position and tell the radio operator to cut the liaison transmitter off, to reduce the load on the electrical system.

When substituting one receiver for another, such as the compass receiver for the command receiver, the pilot must move his interphone selector switch to the "COMMAND" or "LIAISON" position, as the case may be, in order to transmit. At the end of the transmission, he must switch back to the position of the receiver being used. He must do this every time he desires to hold a 2-way conversation.

THE C-1 AUTO PILOT



The C-1 autopilot is an electromechanical robot which automatically controls the airplane in straight and level flight, or maneuvers the airplane in response to the fingertip control of the human pilot or bombardier.

Actually, the autopilot works in much the same way as the human pilot in maintaining straight and level flight, in making corrections necessary to hold a given course and altitude, and in applying the necessary pressure on the controls to turns, banks, etc. The difference is that the autopilot acts instantaneously and with a precision that is not humanly possible.

The precision of even the most skillful human pilot is limited by his own reaction time, i.e., the interval between his perception of a certain condition and his action to correct or control it. Reaction time itself is governed by such human fallibilities as fatigue, inability to detect errors the instant they occur, errors in judgment and muscle coordination.

The autopilot, on the other hand, detects flight deviations the instant they occur, and just as instantaneously operates the controls to correct the deviations. Properly adjusted, the autopilot will neither overcontrol nor undercontrol the airplane, but will keep it flying straight and level with all 3 control surfaces operating in full coordination.

How It Works

The C-1 autopilot consists of various separate units electrically interconnected to operate as a system. The operation of these units is explained in detail in AN-11-60AA-1. A general over-all understanding of their functions and relation to each other can be acquired by studying the accompanying illustration.

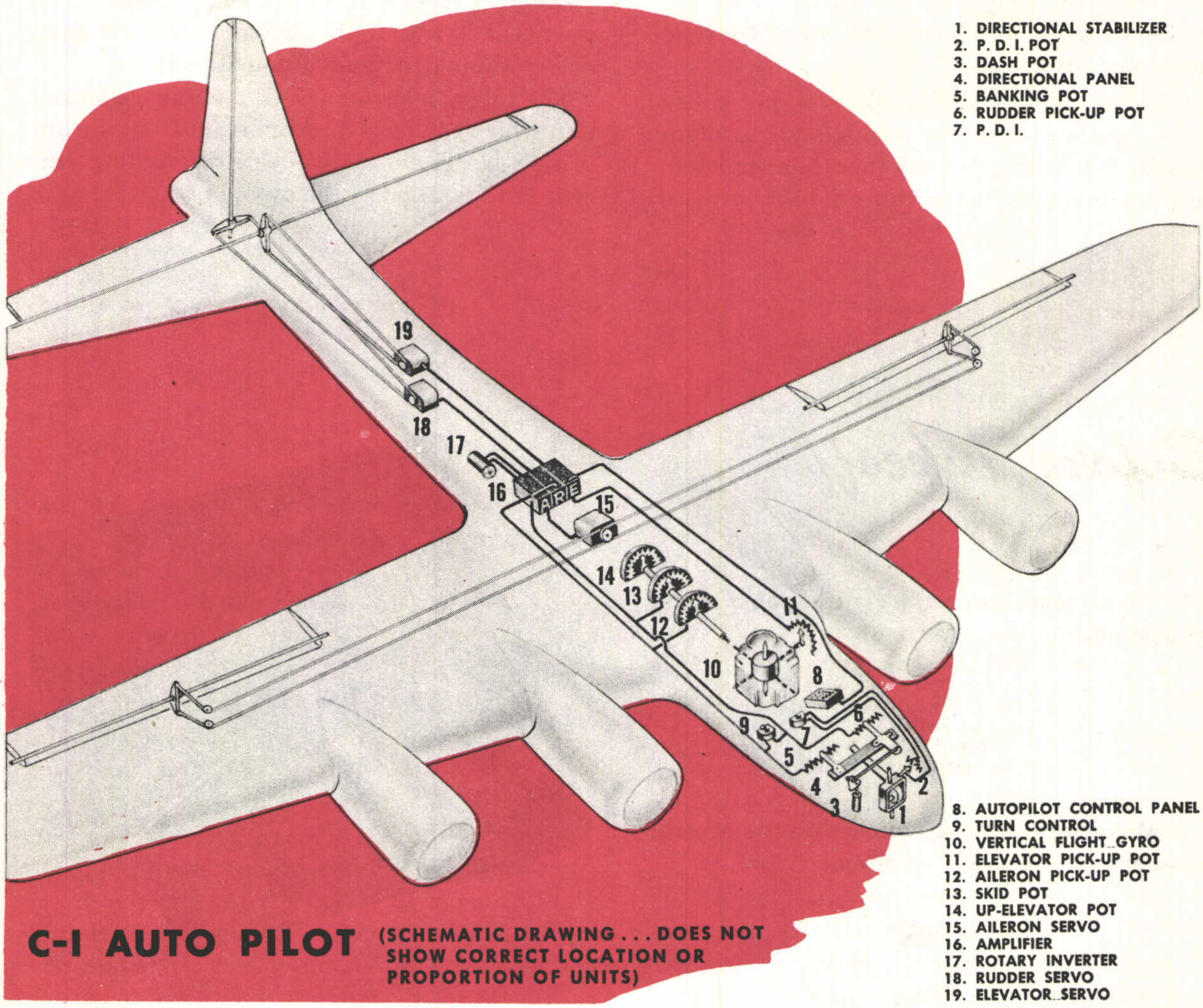
Assume that the airplane in the illustration is flying straight and level and that the autopilot is at work.

Suddenly rough air turns the airplane away from its established heading. The gyro-operated directional stabilizer (1) in the bombardier's compartment detects this deviation and moves the directional panel (4) to one side or the other, depending upon the direction of the deviation.

The directional panel contains 2 electrical devices, the banking pot (5) and the rudder pick-up pot (6), which send signals to the aileron and rudder section of the amplifier (16) whenever the directional panel is operated. These signals are amplified and converted (by means of magnetic switches or relays) into electrical impulses which cause the aileron and rudder Servo units (15 and 18) to operate the ailerons and rudder of the airplane in the proper direction and amount to turn the airplane back to its original heading.

Similarly, if the nose of the airplane drops, the vertical flight gyro (10) detects the vertical deviation and operates the elevator pick-up pot (11) which sends an electrical signal to the elevator section of the amplifier. The signal is amplified and relayed in the form of electrical impulses to the elevator Servo unit (19) which in turn raises the elevators the proper amount to bring the airplane to level flight.

If one wing drops appreciably, the vertical flight gyro operates the aileron pick-up pot (12), the skid pot (13), and the up-elevator pot (14). The signals caused by the operation of these units are transmitted to their respective (aileron, rudder, and elevator) sections of the amplifier. The resulting impulses to the



1. DIRECTIONAL STABILIZER
2. P. D. I. POT
3. DASH POT
4. DIRECTIONAL PANEL
5. BANKING POT
6. RUDDER PICK-UP POT
7. P. D. I.
8. AUTOPILOT CONTROL PANEL
9. TURN CONTROL
10. VERTICAL FLIGHT GYRO
11. ELEVATOR PICK-UP POT
12. AILERON PICK-UP POT
13. SKID POT
14. UP-ELEVATOR POT
15. AILERON SERVO
16. AMPLIFIER
17. ROTARY INVERTER
18. RUDDER SERVO
19. ELEVATOR SERVO

C-1 AUTO PILOT (SCHEMATIC DRAWING . . . DOES NOT SHOW CORRECT LOCATION OR PROPORTION OF UNITS)

aileron, rudder, and elevator Servo units cause each of these units to operate its respective control surface just enough to bank and turn the airplane back to a level-flight attitude.

When the human pilot wishes to make a turn, he merely sets the turn control knob (9) at the degree of bank and in the direction of turn desired. This control sends signals, through the aileron and rudder sections of the amplifier, to the aileron and rudder Servo units which operate ailerons and rudder in the proper manner to execute a perfectly coordinated (non-slipping, non-skidding) turn. As the airplane banks, the vertical flight gyro operates the aileron, skid, and up-elevator pots (12, 13, 14). The resulting signals from the aileron and skid pots cancel the signals to the aileron and rudder Servo units to streamline these controls during the turn.

The signals from the up-elevator pot cause the elevators to rise just enough to maintain altitude. When the desired turn is completed, the pilot turns the turn control back to zero and the airplane levels off on its new course. A switch in the turn control energizes the directional arm lock on the stabilizer, which prevents the stabilizer from interfering with the turn by performing its normal direction-correcting function.

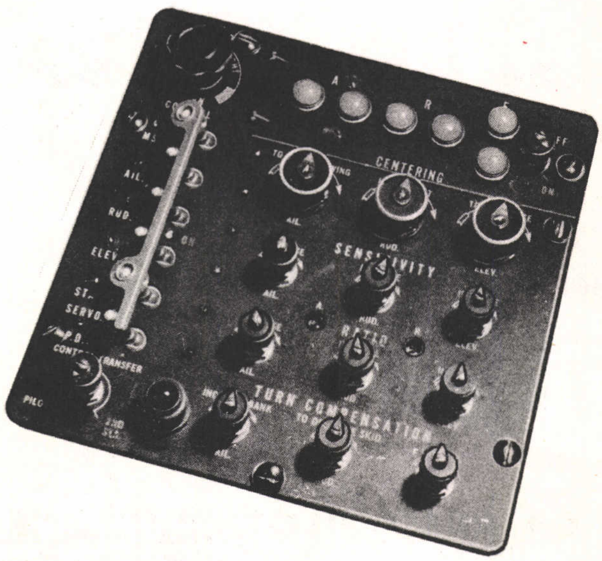
The autopilot control panel (8) provides the pilot with fingertip controls by which he can conveniently engage or disengage the system, adjust the alertness or speed of its responses to flight deviations, or trim the system for varying load and flight conditions.

The pilot direction indicator, or PDI (7), is a remote indicating device operated by the PDI pot (2). When the autopilot is used, the PDI indicates to the pilot when the system and airplane are properly trimmed. Once the autopilot is engaged, with PDI centered, the autopilot makes the corrections automatically.

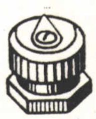
The rotary inverter (17) is a motor-generator unit which converts direct current from the airplane's battery into 105-cycle alternating current for operation of the autopilot.

HOW TO OPERATE THE C-1 AUTOPILOT

Before Takeoff

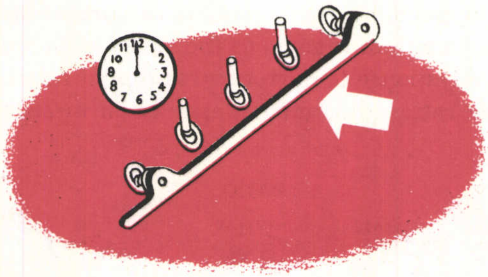


1. Set all pointers on the control panel in the up position.



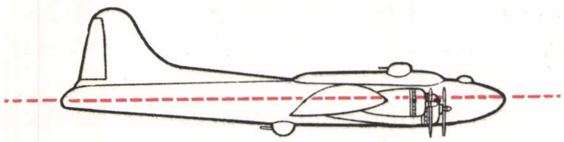
2. Make sure that all switches on the control panel are in the "OFF" position.

After Takeoff

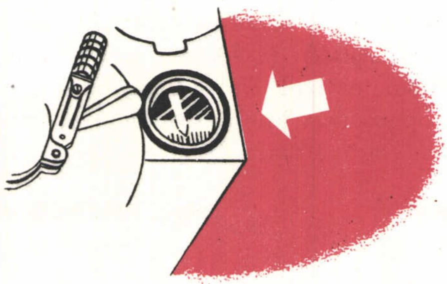


1. Turn on the master switch.

2. Five minutes later, turn on PDI switch (and Servo switch, if separate).

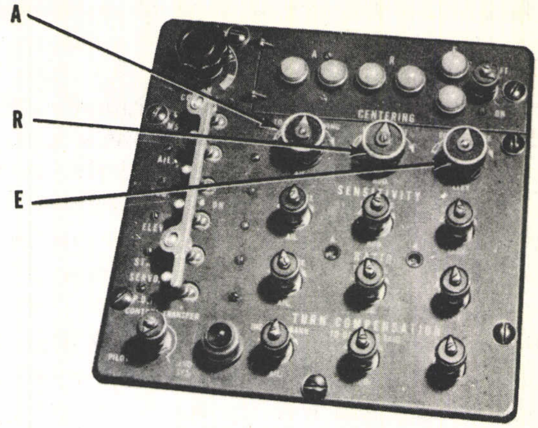


3. Ten minutes after turning on the master switch, trim the airplane for level flight at cruising speed by reference to flight instruments.

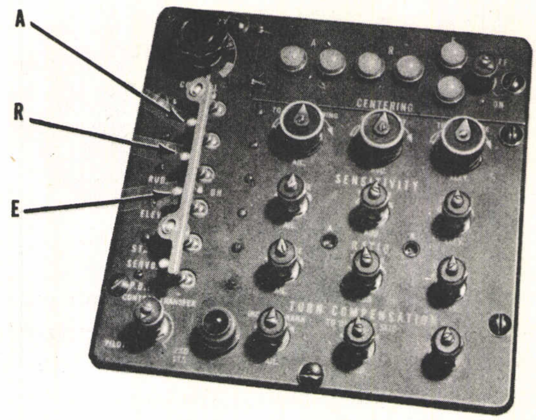


4. Have the bombardier disengage the autopilot clutch, center PDI and lock it in place by depressing the directional control lock. The PDI is held centered until the pilot has completed the engaging procedure. Then the autopilot clutch is re-engaged, and the directional arm lock released.

Alternate Method: The pilot centers PDI by turning the airplane in direction of the PDI needle. Then resume straight and level flight.



5. Engage the autopilot. Put out aileron telltale lights with the aileron centering knob, then throw on the aileron engaging switch. Repeat the operation for rudder, then for elevator.



6. Make final autopilot trim corrections. If necessary, use centering knobs to level wings and center PDI.

Caution:

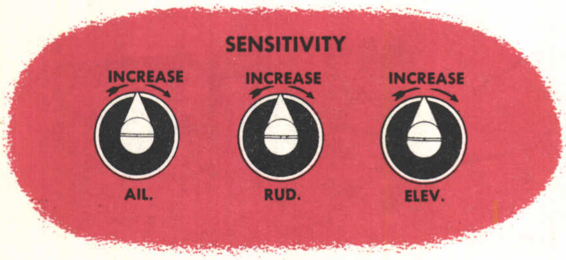
NEVER ADJUST MECHANICAL TRIM TABS WHILE THE AUTOPILOT IS ENGAGED

FLIGHT ADJUSTMENTS AND OPERATION

After the C-1 autopilot is in operation, carefully analyze the action of the airplane to make sure all adjustments have been properly made for smooth, accurate flight control.

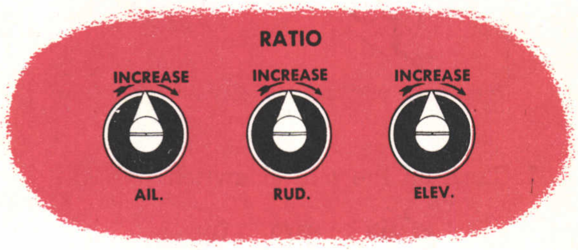
When both **tell-tale** lights in any axis are extinguished, it is an indication the autopilot is ready for engaging in that axis.

Before engaging, each **centering knob** is used to adjust the autopilot control reference point to the straight and level flight position of the corresponding control surface. After engaging, centering knobs are used to make small attitude adjustments.



Sensitivity is comparable to a human pilot's reaction time. With sensitivity set high, the autopilot responds quickly to apply a correction for even the slightest deviation. If sensitivity is set low, flight deviations must be relatively large before the autopilot will apply its corrective action.

Ratio is the amount of control surface movement applied by the autopilot in correcting a given deviation. It governs the speed of the airplane's response to corrective autopilot actions. Proper ratio adjustment depends on airspeed.



If ratio is too high, the autopilot will overcontrol the airplane and produce a ship hunt; if ratio is to low, the autopilot will undercontrol and flight corrections will be too slow. After ratio adjustments have been made, centering may require readjustment.

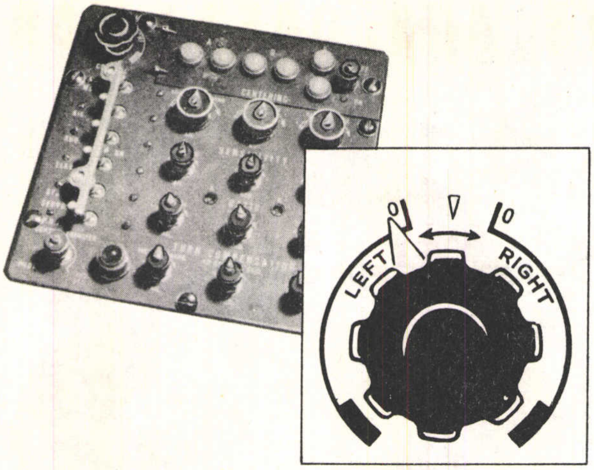
To adjust **turn compensation,** have bombardier disengage autopilot clutch and move engaging knob to extreme right or extreme left. Airplane should bank 18° as indicated by artificial horizon. If it does not, adjust aileron compensation (bank trimmer) to attain 18° bank. Then, if turn is not coordinated, adjust rudder compensation (skid trimmer) to center inclinometer ball. Do not use aileron or rudder compensation knobs to adjust coordination of turn control turns.

Emergency Use of Autopilot

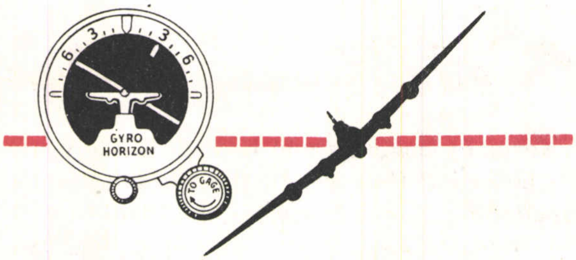
REMEMBER THE ROLE THAT THE AUTOPILOT CAN PLAY IN EMERGENCIES

1. If the control cables are damaged or severed between the pilot's compartment and the Servo units in the tail, the autopilot can bridge the gap. There have been many instances where the autopilot has been used thus to fly an airplane with damaged controls.

2. If the autopilot has been set up for level flight, it can be used to hold the airplane straight and level while abandoning ship.

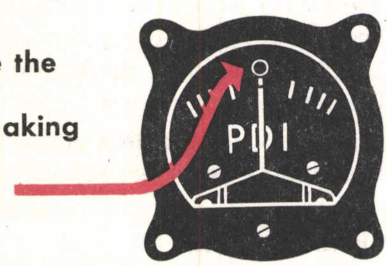


The **turn control** is used by the pilot to turn the airplane while flying under automatic control. To adjust turn control, first make sure turn compensation adjustments have been properly made, then set turn control pointer at beginning of trip-lined area on dial. Airplane



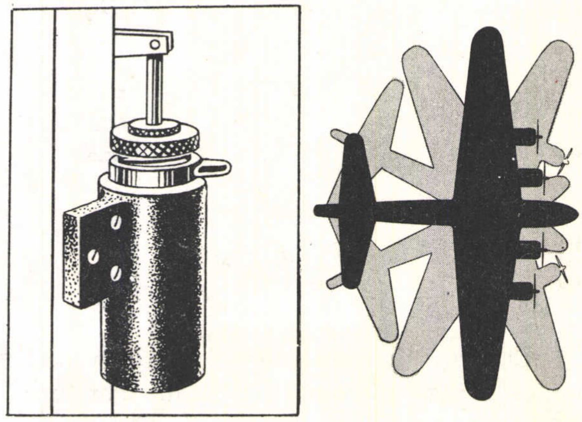
should bank 30°, as indicated by artificial horizon. If it doesn't, remove cap from aileron trimmer and adjust trimmer until a 30° bank is attained. Then, if turn is not coordinated (inclinometer ball not centered), adjust rudder trimmer to center ball. Make final adjustments with both trimmers and replace caps. Set turn control at zero to resume straight and level flight; then re-center.

Never operate the Turn Control without first making sure the PDI is centered



The **turn control transfer** has no effect unless the installation includes a remote turn control.

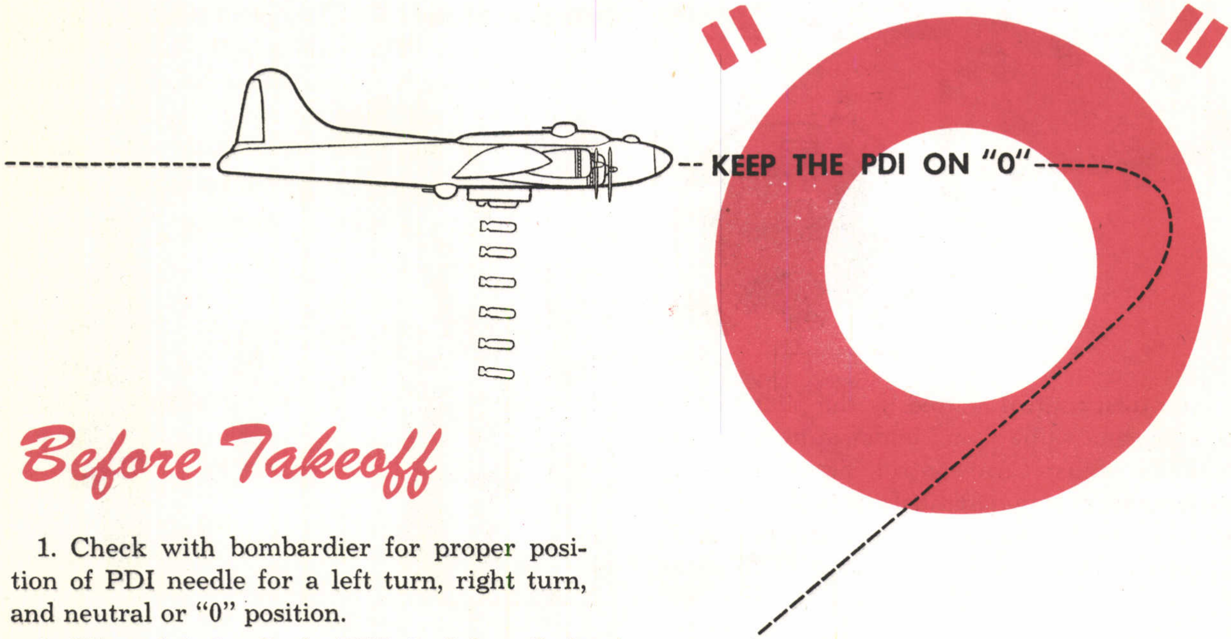
The **dashpot** on the stabilizer regulates the amount of rudder kick applied by the autopilot to correct rapid deviations in the turn axis. If a rudder hunt develops which cannot be eliminated by adjustment of rudder ratio or sensitivity, the dashpot may require adjustment.



This is accomplished by loosening the locknut on the dashpot, turning the knurled ring up or down until hunting ceases, then tightening the locknut.

Cold Weather Operation—When temperatures are between —12° and 0°C (10° and 32°F) autopilot units must be run for 30 minutes before engaging. If accurate flight control is desired immediately after takeoff, perform the autopilot warm-up before takeoff by turning on the master switch during the engine run-up—but make sure autopilot is off during takeoff. If warm-up is performed during flight, allow 30 minutes after turning on master switch before engaging. When temperatures are below —12°C (10°F) units must be preheated for one hour before takeoff. Use special heating covers or blankets with heating tubes.

FLYING THE PDI MANUALLY



Before Takeoff

1. Check with bombardier for proper position of PDI needle for a left turn, right turn, and neutral or "0" position.

2. When bombardier's PDI is left, pilot's PDI is right, and vice versa.

On the Bombing Run

Normally bombing will be done while using the autopilot. However, if the autopilot is not functioning the pilot may use the PDI.

1. To center the PDI needle, turn the airplane in the direction of the needle.

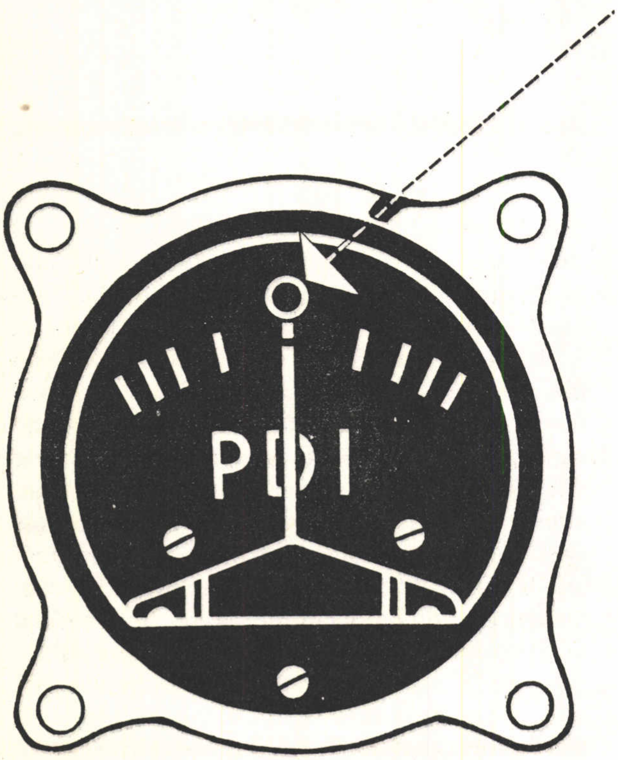
2. At the beginning of the bombing run, the pilot usually can expect maximum PDI corrections. Avoid tendency to overcorrect by refraining from leading the needle.

3. No matter how slight the deviation of the PDI needle from "0," the needle must be returned to "0" immediately.

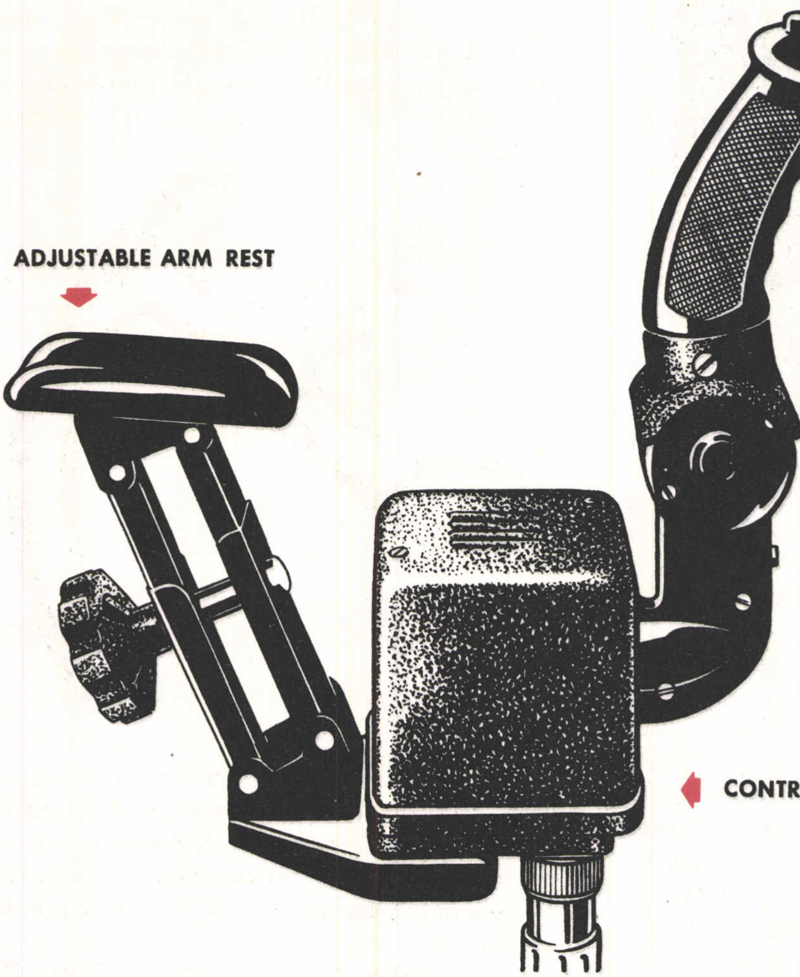
4. Set turns must be coordinated aileron and rudder turns, in order to make the desired degree of turn more rapidly and to avoid any excessive sliding of the bombsight lateral bubble and induced precession of the gyro.

5. To avoid tumbling of the bombsight gyro, banks must never exceed 18°.

6. Keep PDI on "0" until bombardier calls "Bombs away."



THE FORMATION STICK

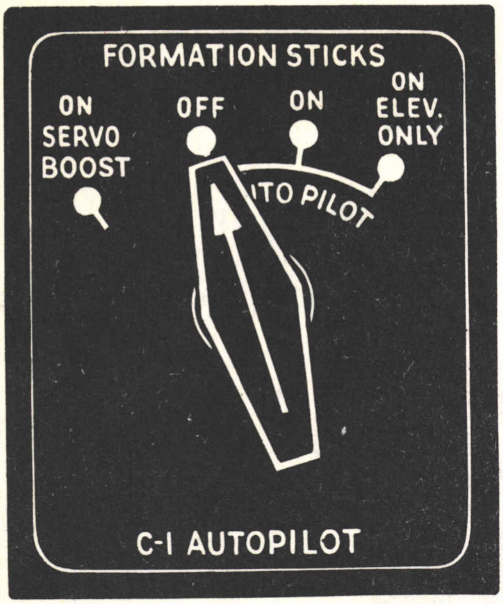


The formation stick is a miniature control stick, working through the autopilot, that enables you and your copilot to maneuver your airplane quickly and with a minimum of effort. You use the formation stick as you would the control stick of a primary trainer—forward and back for descents and climbs, sideways for banks. Sideways movement of the stick controls both ailerons and rudders in coordination, eliminating the need for separate rudder control. Movement of the stick electrically actuates the servo units of the autopilot, which in turn move the control surfaces.

There are two sticks, one on the pilot's left, the other on the copilot's right. Only one stick is engaged at a time; transfer switches shift control of the airplane from the pilot's stick to the copilot's, and vice versa. Push-to-talk trigger switches on both formation sticks control the radio microphones.

There is a four-position function selector that determines to what extent the formation stick will control the airplane. These positions are:

1. "OFF"—In this position the autopilot operates normally and flys the airplane, the stick having no control.



2. "ON SERVO BOOST"—The stick is in direct control of the autopilot servos and you must use it as if it were mechanically linked to the surface controls. Use this position when you want quick maneuvering, as in a wing position of a tight formation.

3. "ON ELEV. ONLY"—The stick provides only vertical control of the airplane, the autopilot controlling ailerons and rudder. The bombardier makes turns with the bombsight autopilot attachment, or the pilot can use the autopilot turn control. Use this position when the bombardier has control of the airplane.

4. "ON"—The autopilot is flying the airplane, with the stick working like the autopilot turn control, except that it provides vertical as well as bank control. Use this position when leading a formation, in a wing position of a loose formation, or in other situations where little maneuvering is required.

How to Use

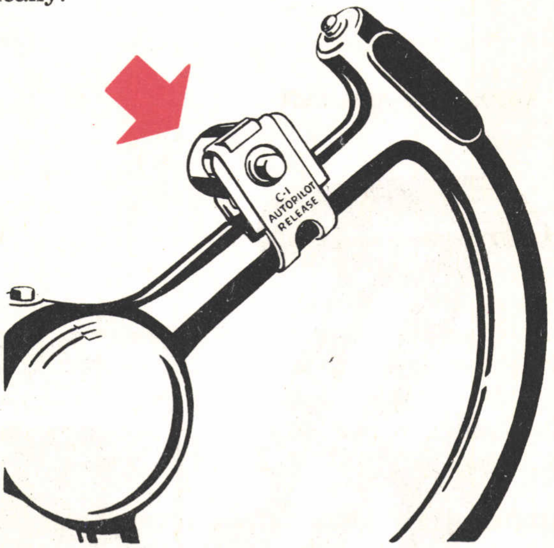
1. Before takeoff, check both autopilot master switch and the formation stick function selector in the "OFF" position.

2. In flight, when ready to use the formation stick, set up the autopilot in the normal manner.

3. Engage the formation stick by turning function selector to "ON," "ON SERVO BOOST," or "ON ELEV. ONLY," depending upon the type of operation desired.

To Transfer Control

To transfer control from pilot stick to copilot stick, push the button on top of the copilot stick. To regain control, the pilot pushes his button. If both buttons are pressed at the same time, the pilot gets control. When the formation stick is first engaged, the pilot has control automatically.



To Disengage Stick

An autopilot release switch on the wheel of each regular control column permits either pilot or copilot to return the airplane to manual control. Momentary pressure on either switch immediately disengages all three autopilot servos.

To re-engage the formation stick after the release switch has been used, turn off all autopilot switches, retrim the airplane, and then engage autopilot and formation stick in the normal manner.

However, if the release switch is pressed accidentally and **the formation stick has not been moved while the autopilot is disengaged,** you can re-engage the formation stick by snapping the autopilot switch off and then right on again, turning the other autopilot switches on without the usual adjustments. Do not use this method unless you are sure the formation stick has not been moved while the autopilot was off.

Pilot's Operating Instructions

SUGGESTED ENGAGING PROCEDURE FOR LEAD AIRPLANE

1. After take-off, check that the function selector is in the "OFF" position.
2. Turn the tell-tale light shutter switch on.
3. Center the turn control knob.
4. Place the turn control transfer knob to "Pilot" position.
5. Turn on C-1 master switch.
6. Manually trim airplane for desired flight attitude.
7. Set all C-1 control knobs to "pointers up" position.

Note: All controls must be previously adjusted in flight by competent personnel for best performance under expected conditions and this adjustment indexed by fixing the pointers in the "Up" position.

8. Turn on PDI and servo switch 10 minutes after turning on master switch.
9. Have Bombardier disengage autopilot clutch arm to center PDI; and press down on directional arm lock to keep PDI centered.
10. Put out aileron tell-tale lights by adjusting aileron centering knob.
11. Snap aileron switch on.
12. Check gyro horizon and readjust aileron centering to level wings.
13. Put out rudder tell-tale lights with rudder centering knob.
14. Snap rudder switch on.
15. Have Bombardier re-engage autopilot clutch and release directional arm lock.
16. Readjust rudder centering knob to center PDI if necessary.
17. Put out elevator telltale lights with elevator centering knob.
18. Snap elevator switch on.
19. Readjust elevator centering if necessary.
20. Turn function selector to "ON" position. The formation sticks may now be used to make coordinated turns up to approximately 25° of bank and also to control the elevator.

SUGGESTED ENGAGING PROCEDURE FOR WING AIRPLANES

1. After take-off, turn the function selector to the "ON SERVO BOOST" position.
2. Turn the tell-tale light shutter switch on.
3. Center turn control knob.
4. Place turn control transfer knob in "Pilot" position.
5. Have bombardier disengage autopilot clutch, move clutch arm to center PDI, and press down on Directional Arm Lock to keep the PDI centered.
6. Turn on C-1 master switch. (This will lock the directional arm.)
7. Have bombardier re-engage autopilot clutch and remove hand from directional arm lock.
8. Manually trim airplane for desired flight attitude.
9. Set all C-1 control knobs to "Pointers Up" position.

Note: All controls must be previously adjusted in flight by competent personnel for best performance under expected conditions and this adjustment indexed by fixing the pointers in the "Up" position.

10. Turn on PDI and servo switch, not less than one minute after the master switch was engaged. Note: If Function Selector is left in the "ON SERVO BOOST" position, it is not necessary to wait ten minutes for the gyros to erect.
11. Put out aileron tell-tale lights by adjusting aileron centering knob.
12. Snap on aileron switch.
13. Use formation stick to maintain aileron control as soon as aileron switch is snapped on.
14. Put out rudder tell-tale lights by adjusting rudder centering knob.
15. Snap on rudder switch.
16. Use formation stick for both aileron and rudder control after rudder switch is snapped on.
17. Put out elevator tell-tale lights by adjusting elevator centering knob.
18. Snap on elevator switch. The formation

stick can now be used to control the flight of the airplane in all axes.

The function selector knob may be turned to any one of the four positions: "ON SERVO BOOST," "OFF," "ON," or "ELEV. ONLY" to give the desired control.

"ON SERVO BOOST" Position

This selector setting is to be used when flying a wing position in a tight formation or whenever quick maneuvering is desired.

To maneuver the airplane, move the stick in the same manner as a manual control stick would be moved.

The three centering knobs may be used to trim the airplane for the desired attitude with the stick in the normal center position.

Do not adjust the turn control trimmers during "ON SERVO BOOST" operation.

Aileron and rudder ratio may be adjusted to coordinate the controls for going into a bank or coming out of one but will have no effect while the controls are streamlined in the bank. Therefore, some slipping will be noticed in steep continuous banks.

Do not attempt to adjust the dashpot during "ON SERVO BOOST" operation since the dashpot has no effect on the operation of the autopilot with the directional arm lock engaged.

"OFF" Position

Whenever it is desired to fly on autopilot without using the sticks, turn the selector to "OFF."

"ON" Position

Use this selector position when leading a formation, in a wing position of a loose formation, or when very little maneuvering is desired, such as for course corrections on cross-country flights. In the "ON" position the stick is handled in the following manner:

1. For straight and level flight, leave the stick in center, and the autopilot will automatically maintain straight and level flight.

2. To climb or glide, move the stick backward or forward a distance sufficient to produce the desired change in attitude, and hold it there until ready to return to level flight. Release the stick or return it to center to return the airplane to level flight.

3. For a turn, move the stick from center in the desired direction a distance sufficient to produce the desired bank and turn. Maximum bank obtainable is approximately 25 degrees. Hold the stick in that position until the turn is complete. Return the stick to center to come out of the turn.

Streamlining of controls and application of up-elevator in the turn are automatically accomplished by the vertical flight gyro of the autopilot. More or less elevator may be applied by moving the stick forward or backward. Coordination of turns may be adjusted with the turn control trimmers.

Sensitivity and ratio adjustments may be made for flight conditions. If there is a tendency of the airplane to hunt in the turn axis, the dashpot may require adjusting.

Centering adjustments of the aileron, rudder, and elevator centering knobs may be used to adjust the attitude of the airplane. Make adjustments only with the stick centered.

"ON ELEV. ONLY" Position

Use this position when the bombardier has control. Hold the stick back to climb, in a forward position to dive. The rate of climb or dive will be governed by the distance the stick moved from center. Movement of the stick to right or left will have no effect. Turns may be made by the directional panel (bombardier) or the autopilot turn control.

Changing Function Selector Position

Always hold the airplane level while changing the selector from one position to another.

Make sure that the PDI is on zero before changing from any position to "ON SERVO BOOST." This is necessary to insure that the erecting cut-out switch in the directional panel is not closed when the directional arm is locked.

The autopilot master switch must have been on for at least 10 minutes before the function selector is moved from the "ON SERVO BOOST" position in order to give the autopilot gyros time to erect. If banks have exceeded 40 degrees the autopilot gyros may have tumbled and the function selector should not be moved from "ON SERVO BOOST" position for at least 10 minutes after the last steep bank.

TIPS ON USING FORMATION STICK

1. Make sure PDI is on zero before turning function selector "ON SERVO BOOST" position. Otherwise an abrupt turn may result.

2. Remember that with the selector in "ON SERVO BOOST" position the autopilot has no control. Use the formation stick as if it were a manual control.

3. Don't use the autopilot turn control when the selector is in "ON SERVO BOOST" position.

4. Don't exceed 40° banks; the autopilot gyro may tumble. A tumbled gyro will not affect the flying characteristics while the selector is in "ON SERVO BOOST" position. However, when the function selector is moved to any other position a sudden maneuver results. If you do exceed a 40° bank fly the airplane straight and level for about 10 minutes to allow the gyro to right itself before turning the function selector from "ON SERVO BOOST" position.

5. Don't use the formation stick as a handhold or hat-rack. You can break it.

6. Don't use the formation stick for landing unless your manual controls fail. The stick doesn't provide separate aileron and rudder control, and provides less movement of control surfaces than manual operation.

7. Since the formation stick works through the autopilot, remember to observe the same precautions when using it as you do when using the autopilot alone.

8. Don't expect the formation stick to work properly unless the autopilot is functioning as it should. Use the autopilot ground checklist prior to flight.

PILOT'S GROUND CHECKLIST FOR FORMATION STICK

1. Complete the autopilot ground check, with the exception of the last step, leaving the autopilot engaged.

2. Set the formation stick function selector at "ON."

3. Move pilot's stick to the extreme right. The control wheel should turn clockwise, and the right rudder pedal should move forward. Make same check to the left.

With the stick held off center, have the directional arm lock on the directional stabilizer checked, to make sure that the arm is held securely. Then release the stick and see that it returns to center automatically, returning control wheel and rudder pedals to center as it moves.

With the formation stick in center, make sure the directional arm lock is released.

4. Move the formation stick forward, then back. The control column should follow the stick movement, and when stick is released both stick and control column should return to center automatically.

5. Press transfer button on top of copilot's stick, to give his stick control. Then repeat the above check. Transfer control back to pilot's stick.

6. Move the function selector to "ON SERVO BOOST." Then move the stick to each side and forward and back, making sure that all controls move in the proper directions. The control response should be the same as with the function selector at "ON," except that the aileron and rudder controls may not move as far.

7. Move function selector to "ON ELEV. ONLY." Then move pilot's stick backward and forward to check operation of elevator control. The control column should move only about one-third as far as it does with the function selector in the "ON" position. Movement of the stick sideways should not affect the ailerons or rudders.

8. Press the transfer button on the copilot's stick and move the stick to make sure that this stick now has control.

9. Press the autopilot release switch on the copilot's control wheel and check operations of controls to make sure they operate freely and autopilot is disengaged.

10. Snap the autopilot master switch "OFF," then immediately back "ON," and re-engage the remaining autopilot switches.

11. Move pilot's stick to make sure it has regained control.

12. Press autopilot's release switch on pilot's control wheel and check operation of controls to make sure they operate freely and autopilot is disengaged.

13. Check operation of pilot's and copilot's microphone switches. To check, turn radio control switch to "INTER-COM" position. Then squeeze trigger on each formation stick, while using microphone and listening on headset.

14. Move function selector to "OFF," and turn off autopilot master switch.

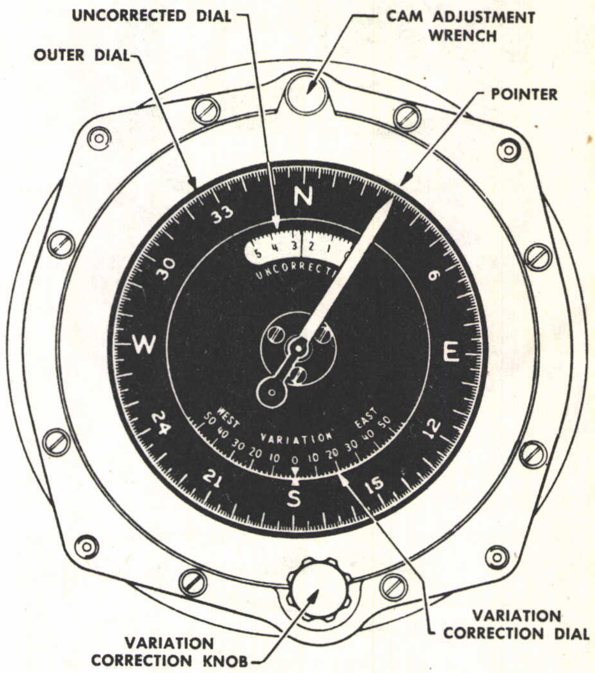
PILOT'S GROUND CHECKLIST FOR THE C-1 AUTOPILOT

1. Center turn control.
2. Turn on C-1 master switch bar.
3. Set control transfer knob at "PILOT."
4. Set tell-tale shutter switch "ON."
5. Set all adjustment knobs to pointers-up position, making sure pointers are not loose.
6. Tell bombardier to center PDI.
7. Turn on Servo PDI switch.
8. Operate controls through extreme range several times, observing that tell-tale lights flicker and go out as streamline position is reached from either direction.
9. Turn on aileron, rudder, and elevator switches.
10. Turn aileron centering knob clockwise, then counter-clockwise, observing that wheel turns to the right and then to the left.
11. Repeat Item 10 for rudder and elevator, observing action.
12. Have bombardier move directional arm for full right turn, then to left, observing to see if aileron and rudder move in proper direction.
13. Have bombardier center PDI and engage secondary clutch.
14. Rotate turn control knob for right and left turns, observing aileron and rudder controls for proper movement.
15. If all checks are satisfactory, turn the C-1 master switch bar "OFF."

THE GYRO FLUX GATE COMPASS

The gyro flux gate compass, remotely located in the wing or tail of the airplane, converts the earth's magnetic forces into electrical impulses to produce precise directional readings that can be duplicated on instruments at all desired points in the airplane.

Unlike the magnetic needle, it will not go off its reading in a dive, overshoot in a turn, hang in rough weather, or go haywire in polar regions.



Development of the Flux Gate

The gyro flux gate compass was developed to fill the need for an accurate compass for long-range navigation. The presence of so many magnetic materials (armor, electrical circuits, etc.) in the navigator's compartment made it almost impossible to find a desirable location for the direct-reading magnetic compass.

To eliminate this difficulty, it became necessary to place the magnetic element of the navigator's compass outside the compartment, **i.e., to use a remote indicating compass.** The unit which is remotely located is called the **transmitter.** The unit used by the navigator is the **master indicator.** For the benefit of the pilot and such other crew members as may have needs for compass readings, auxiliary instruments called **repeater indicators** may be installed in other parts of the airplane.

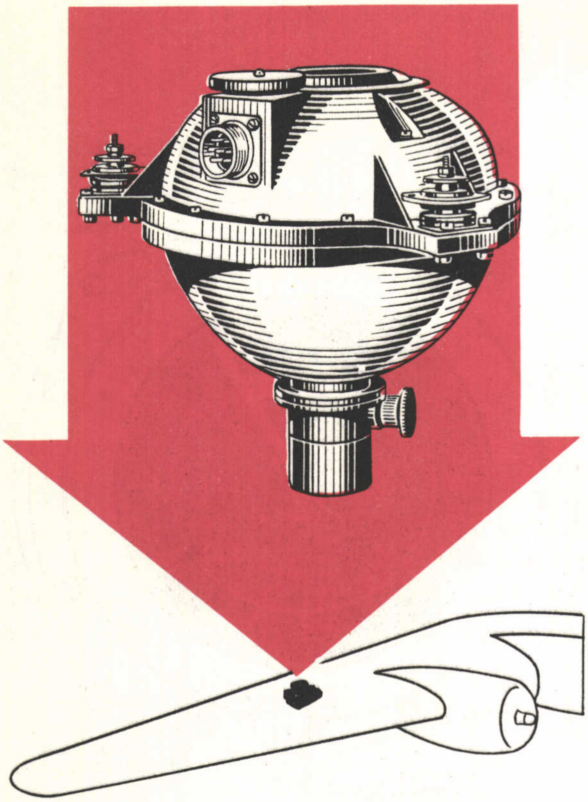
Units of the Flux Gate Compass

The gyro flux gate compass consists of 3 units which are analogous to the brain, heart, and muscles of the human body. The **transmitter,** located in the wing or tail of the airplane, is the brain of the instrument. The **amplifier** is the source of power for the compass and corresponds to the human heart. The **master indicator** does the work of turning a pointer and performs a function similar to that of the muscles in the human body.

1. **The Brain.**—Inside the remotely placed **transmitter** there is a magnetic sensitive element called the flux gate which picks up the direction signal by induction and transmits it to the **master indicator.** This element consists of 3 small coils, arranged in a triangle and held on a horizontal plane by a gyro. Each coil has a special soft iron core, and consists of a primary (or excitation) winding, and a secondary winding from which the signal is obtained.

Because each leg of the flux gate is at a different angle to the earth's magnetic field, and the induced voltage is relative to the angle, each leg produces a different voltage. When the angular relationship between the flux gate and the earth's magnetic field is changed, there is a relative change in the voltages in the 3 legs of the secondary. These voltages are the motivating force for the gyro flux gate compass master indicator which provides indications of the exact position of the flux gate in relation to the earth's magnetic field.

Each coil is a direction sensitive element; but one alone would provide an ambiguous reading because it could tell north from east, for instance, but not north from south. Therefore, it



is necessary to employ 3 coils and combine their output to give the direction signal.

2. **The Heart.**—The amplifier furnishes the various excitation voltages at the proper frequency to the transmitter and master indicator. If amplifies the autosyn signal which controls the master indicator and serves as a junction box for the whole compass system.

Power for the amplifier comes from the airplane's inverter and is converted to usable forms for other units. The input of the amplifier is 400-cycle alternating current and various voltages may be used depending upon the source available.

3. **The Muscle.**—The master indicator is the muscle of the system because it furnishes the mechanical power to drive the pointer on the main instrument dial. The pointer is driven through a cam mechanism which automatically corrects the reading for compass deviation so that a corrected indication is obtained on all headings. The shaft of the pointer is geared to another small transmitting unit in the master indicator which will operate as many as six repeat indicators at other locations.

The amplifier, master indicators and repeaters all are unaffected by local magnetic disturbances.

How to Operate the Compass

1. Leave the toggle switch on the flux gate amplifier "ON" at all times so that the compass will start as soon as the airplane's inverter is turned on.

2. Leave the caging switch in the "UNCAGE" position at all times except when running through the caging cycle.

3. About 5 minutes after starting engines, throw caging switch to "CAGE" position. Leave it there about 30 seconds and then throw to "UNCAGE" again.

4. With the new push button-type caging switch, depress it for a few seconds until a red signal light goes on. Then release the switch and the caging cycle is automatically completed, at which time the red light goes out.

5. Set in the local variation on the master indicator if you wish the pointer to read true heading.

6. If at any time during flight the compass indications lead you to suspect that the gyro is off vertical, run through the caging cycle when the airplane is in normal flight attitude, especially when leveling off after climb.

Note: For further details concerning functions, operation and flight instructions, see Technical Order No. 05-15-27.

EMERGENCY EQUIPMENT

Engine Section Fire Extinguisher

1. Some planes have a remotely controlled fire extinguisher equipment to permit the copilot to discharge CO_2 into the engine accessory compartment. A selector valve for directing the CO_2 to any one of the 4 engines, and 2 pull handles, are on the auxiliary control panel in front of the copilot.

2. Two 7¼-lb. CO_2 cylinders are installed in a gap in the right wing just forward of the rear spar. Control for release of CO_2 from the cylinders is accomplished individually for each cylinder by means of flexible cables extending from the 2 pull handles in the cockpit.

3. To operate, the copilot sets the selector valve to the engine on fire and pulls the handle. Pull the other handle if the second charge of CO_2 is necessary.

Fire Extinguishers

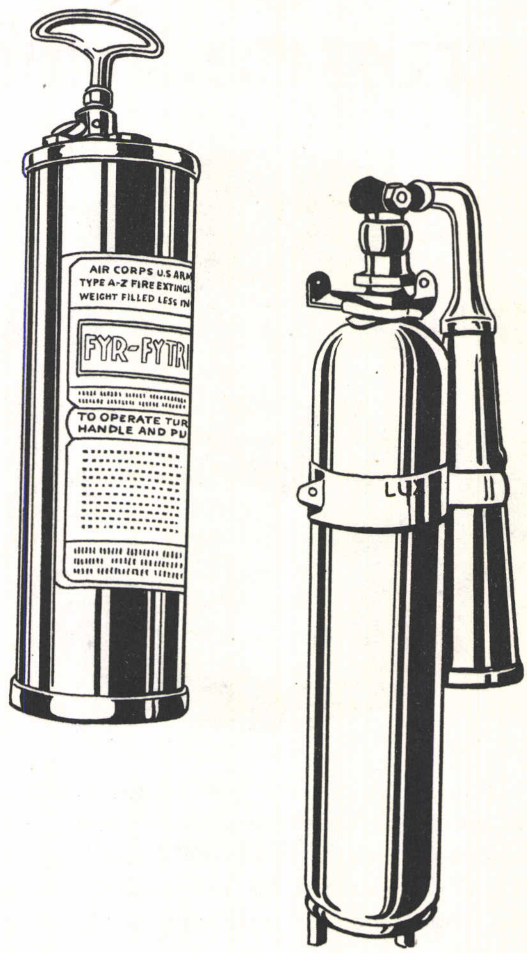
1. There are 3 carbon dioxide fire extinguishers in the B-17: one on the aft bulkhead of the navigator's compartment, one on the right rear bulkhead of the pilot's compartment, and the third on the forward bulkhead of the radio compartment.

To operate—Stand close to fire, raise horn and direct gas to the base of the fire holding onto the rubber insulated tubing. **Warning:** Do not grasp metal horn on top of cylinder; the white gas discharged is "dry ice" and will cause frostbite.

To shut off flow of gas, return horn to position at side of cylinder. Recharge cylinder after each use.

2. Two carbon tetrachloride fire extinguishers are also provided: one at the copilot's left under the seat and one aft of the main entrance door.

To operate—Turn handle and pump plunger, keeping stream full and steady. Stand as far as possible from the fire when using this extinguisher. Effective range is 20 to 30 feet. To shut off, push handle in and turn until sealing plunger is depressed. **Caution:** When sprayed on a fire carbon tetrachloride produces phosgene, an extremely poisonous gas, which can be harmful even in small amounts, and can prove fatal if inhaled. Do not stand near fire. Open windows and ventilators immediately after fire is extinguished.

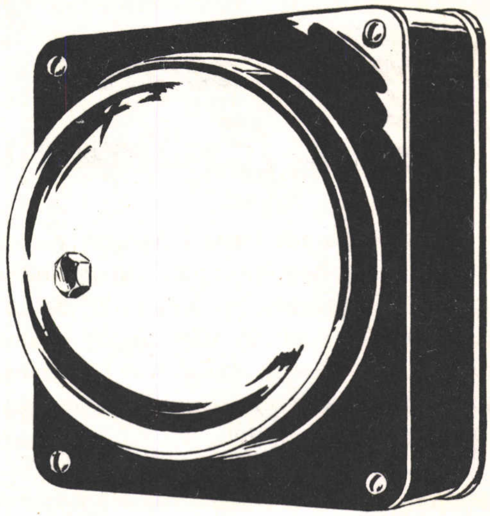


EMERGENCY SIGNAL EQUIPMENT

1. **Alarm Bells:** There are 3 alarm bells on the B-17 for use in emergencies. One is under the navigator's table, one above the radio operator's table, and the third in the tail compartment inside the dorsal fin. A toggle switch on the pilot's control panel controls them.

Operation—Stand by to abandon: Give three short rings. Abandon airplane: One long continuous ring.

2. **Phone Call:** A toggle switch on the pilot's control panel operates 4 amber phone-call signal lamps. Three of them are adjacent to the alarm bells and the fourth is in the tail gunner's compartment on the right side looking aft.



EMERGENCY RADIO TRANSMITTER

1. Some planes have a self-contained portable emergency radio transmitter, stowed on the forward bulkhead of the waist compartment. It is provided for operation anywhere away from the airplane. It is primarily for use in a life raft, but may be operated anywhere a kite may be flown or where a body of water may be found. It has a small parachute to permit dropping from the airplane from an altitude of 300 to 500 feet in an emergency.

2. When operated, the transmitter emits an MCW signal on the international distress frequency of 500 Kc. Automatic transmission of a predetermined signal is provided. Any searching party can make a homing on the signal with the aid of a radio compass.

3. No receiver is provided.

4. Complete operating instructions are contained with the equipment.

5. If emergency landing is made on water, the emergency radio set should be removed at the same time the life raft is removed. The set is waterproof and will float. Be sure the set does not float out of reach.

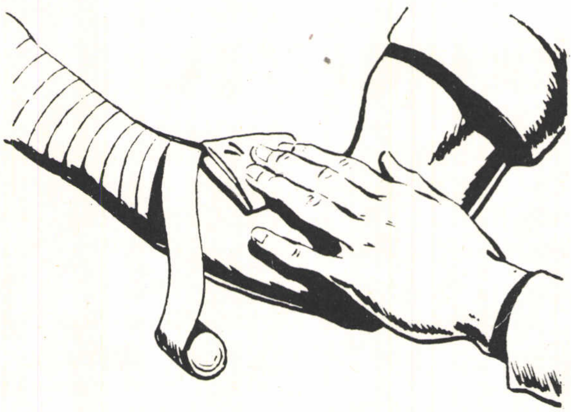
6. To bail out the emergency radio, tie the loose end of the parachute static line to any solid structure of the airplane and throw set through any convenient opening. **Be sure static line does not foul.**

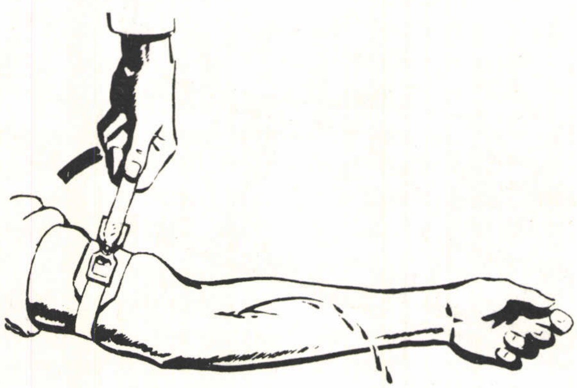
FIRST-AID KITS

1. First-aid kits are on the bombsight storage box, in the navigator's compartment, on the wiring diagram box, on the back of the copilot's seat, and on the bulkhead forward of the lower turret.

2. If first-aid kits are not installed, it is necessary to obtain sufficient number before flight.

3. The first-aid kit, aeronautic, contains the following: tourniquet (1); morphine syrette (2); wound dressing, small (3); scissors (1 pair); sulfanilamide crystals, envelope (1); sulfadiazine tablets (1 box of 12 tables); burn ointment (1 tube) (boric or 5% sulfadiazine); eye dressing set; halazone tablets; 1-inch adhesive compresses (1 box) (contents of small outer pocket); Iodine swabs (10) (contents of small outer pocket):





4. Use—In the case of a wound, first stop the flow of blood. The clothing should be cut away and a compress of wound dressing applied after the sulfanilamide powder has been sprinkled into the wound. If a firmly applied dressing will not stop the bleeding, or if there is actual spurting of blood from an artery, the tourniquet should be applied. A tourniquet must be released every 20 minutes and removed as soon as hemorrhage stops.

5. To relieve severe pain, open the small cardboard container and follow directions given there for the use of the hypodermic syrette of morphine. Do not hesitate to use the hypodermic to relieve suffering.

6. In case of head injury have the man lie quietly with head slightly elevated.

7. In the event of marked blood loss with shock and/or unconsciousness, have the man lie horizontally or lie with the head down, if possible.

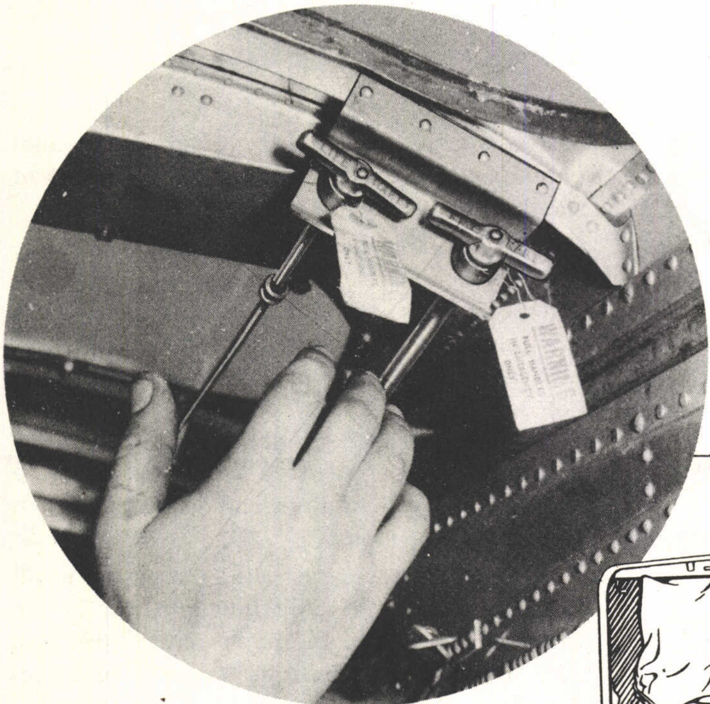
8. An adequate supply of oxygen is doubly important in case of serious injury. Use it generously.

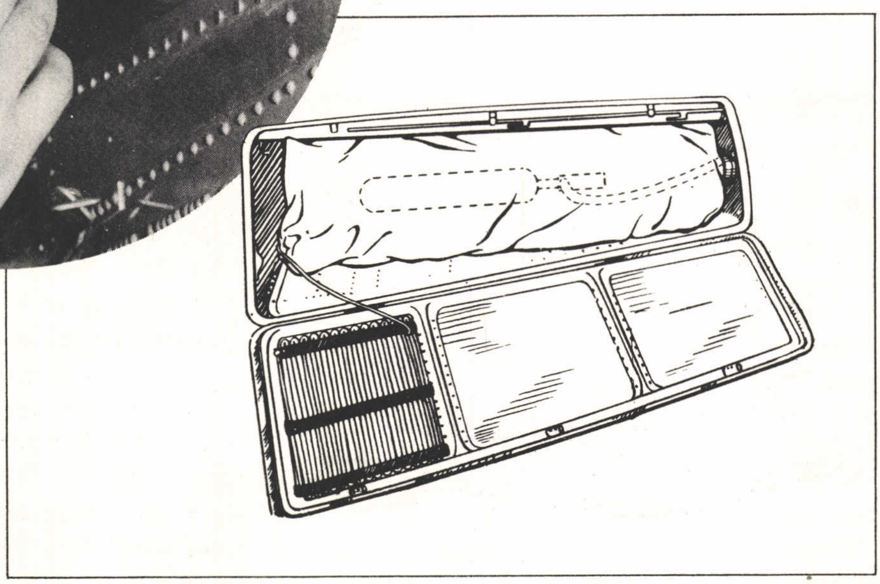
LIFE RAFT

An automatically ejected life raft (Type A-Z or A-3) is carried in each of the 2 life raft compartments in the top of the airplane aft of the top turret. The 2 life rafts are released by 2 pull handles, near the ceiling of the radio compartment just forward of the removable top window. These 2 release handles are clipped into a rack and safety-wired into place to avoid their being pulled by accident. To release a raft completely, pull the handle, hard, out about 12 inches.

The 2 release handles in the radio compartment are attached to the latch mechanism by cables. The functions of the latches are to keep the life raft compartment doors from opening at the wrong time and to insure operation in emergency release. A cable also connects the latch mechanism and the CO_2 bottle valve in the rafts.

Operation—A hard pull of about 12 inches on the release handles in the radio compartment causes the latch mechanism to release the raft compartment doors, and at the same time discharge CO_2 into the raft. Inflation of the raft forces it from the compartment into the water. A mooring line with a low breaking tension is provided to hold the raft in the vicinity of the aircraft. Accessories are provided for use while in the water.





PYROTECHNIC PISTOLS

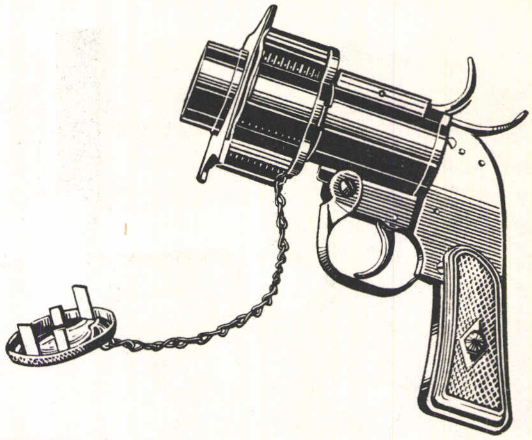
There is a pyrotechnic pistol in the cockpit behind the pilot's seat. Flares are generally mounted on the roof behind the pilot.

When radio communication is inadvisable or when radio equipment fails, brief coded messages may be sent with pyrotechnic signals. Do not use pyrotechnic signals to control important operations unless no other means is available. The various colored signals which are available for use with M2 and AN-M8 pyrotechnic pistols are assigned different meanings under a code that will be changed at frequent intervals in each edition of **Signal Operation Instructions.** The M11 red star parachute signal, however, is always used as a distress signal to be fired from the ground or from a life raft.

M2 Pistol

The M2 pyrotechnic pistol has a strong recoil. Use both hands to fire it if practicable. The signals themselves burn with an extremely hot flame; observe every reasonable precaution while handling or firing them.

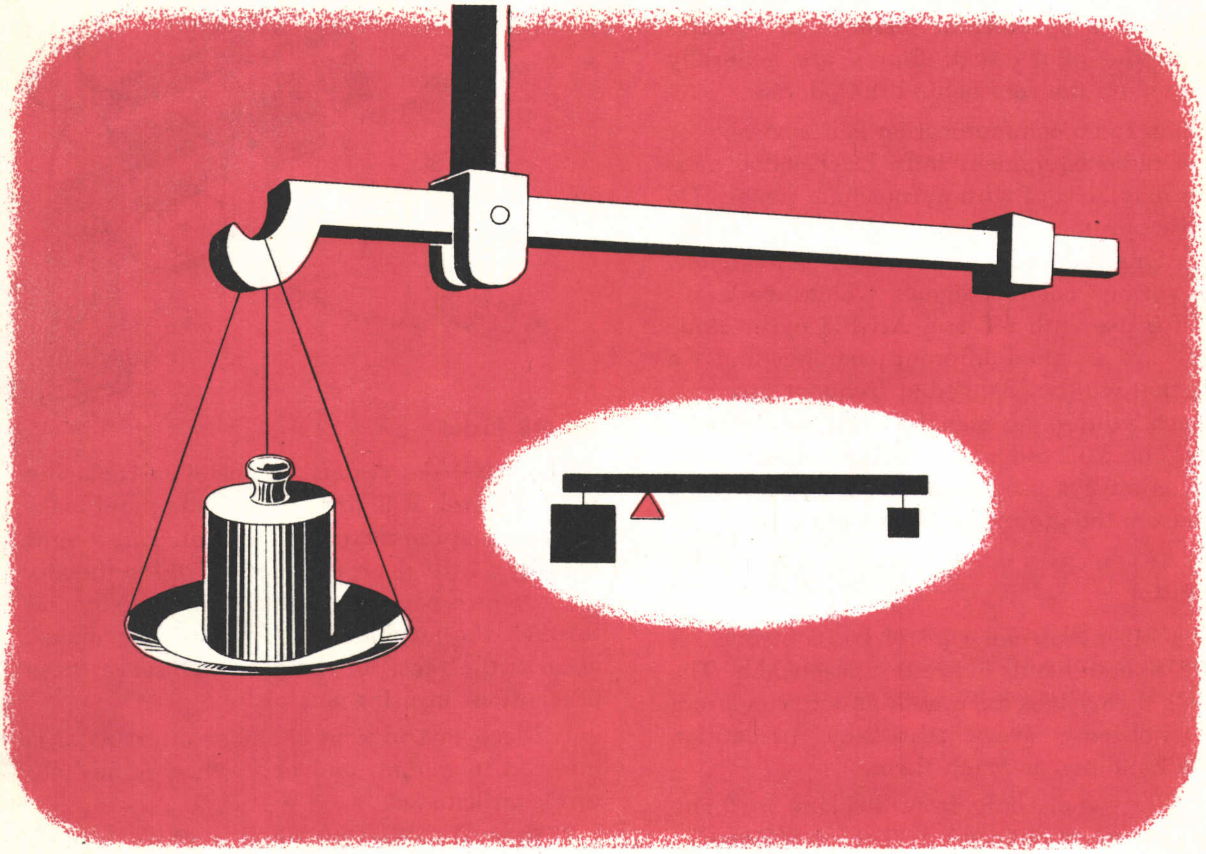
1. Fire signals only from airplane in flight, with the exception of the M11 distress signal.
2. Point the pistol in such a way as to keep signals from striking any part of the plane.
3. If a signal fails to ignite on the first attempt, try at least twice more. If third or final try fails, keep the pistol pointed overboard and clear of all parts of the airplane for at least 30 seconds; then discard signal.
4. Discard a misfired signal, if possible, without handling the signal itself. One method is to hold the pistol over an opening in the airplane and release the cartridge by pressing on the latch and allowing the signal to fall clear under the force of gravity. The force of the air blast prevents holding the pistol outside most airplanes. **Be careful to prevent discarded signal from striking any part of the airplane.**
5. Do not discard misfired signals when flying over populated areas.
6. Fire the M11 distress signal as nearly straight up as is practicable.



AN-M8 Pistol

The AN-M8 pyrotechnic pistol is replacing the M2 pistol. It is fired by inserting and locking the barrel in a type M-1 mount. This mount is really a little door, fastened rigidly to the airplane, which permits the pistol barrel to extend through the airplane's outer skin. The mount absorbs the recoil of the pistol. Observe these precautions in using this pistol:

1. Place cartridge in chamber after pistol is inserted in mount, and only when immediate use is anticipated.
2. Since the pistol is cocked at all times when the breech is closed, **never leave a live signal in the pistol when it is removed from the mount.**



WEIGHT *and Balance*

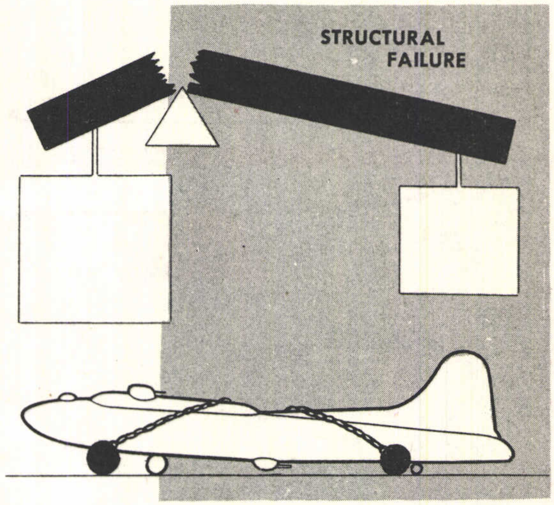
The day when a pilot flew by the seat of his pants is past. One by one the decisions that were made by intuition or hunches have been taken over by an orderly system based on knowledge and understanding. The invariable result has been greater safety and operating efficiency.

The loading of aircraft, especially heavy aircraft, is no exception. The ever-changing conditions of modern airplane operation, resulting in more and more complex combinations of cargo, fuel, crew, and armament, have outmoded rule-of-thumb methods. The necessity for getting the utmost in efficiency out of any given flight has high-lighted the need for a precise system of control over the weight and balance of aircraft.

Improper loading, at best, cuts down the efficiency of an airplane from the standpoint of ceiling, maneuverability, rate of climb, and speed. At worst, it can be the cause of failure to complete a flight—or for that matter, failure even to start it—with probable loss of life and destruction of valuable equipment, because of abnormal stresses upon the airplane or because of changed flying characteristics.

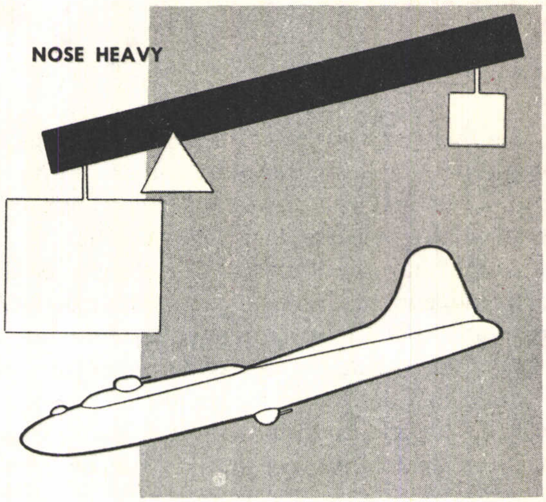
EFFECTS OF IMPROPER LOADING

OVERLOADING



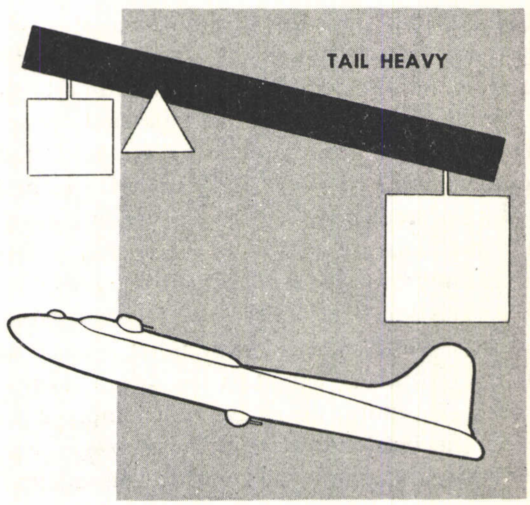
1. Causes a higher stalling speed.
2. Always results in lowering of airplane structural safety factors which may be critical during rough air or takeoffs from poor fields.
3. Reduces maneuverability.
4. Increases takeoff run.
5. Lowers angle and rate of climb.
6. Decreases ceiling.
7. Increases fuel consumption for given speed, which decreases the miles per gallon.
8. Lowers tire safety factors.

CG TOO FAR FORWARD

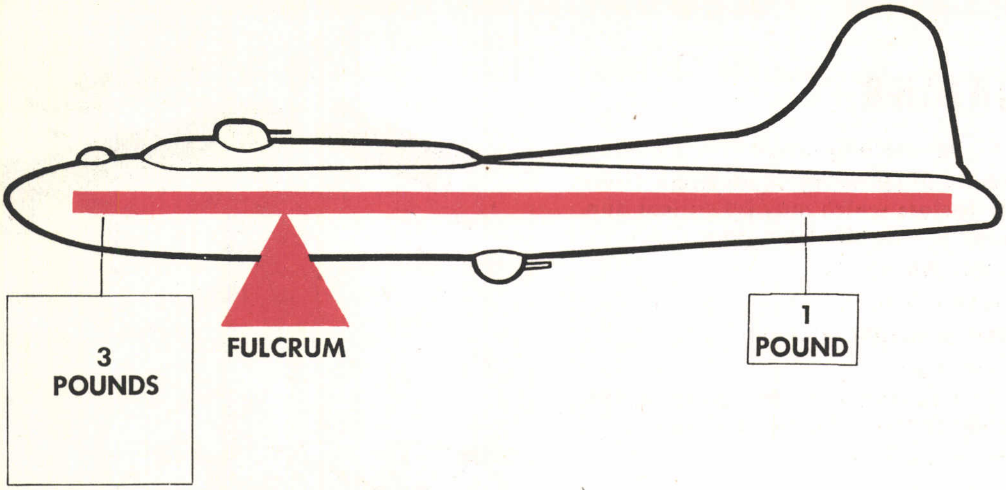


1. Increases fuel consumption (less range).
2. Increases power for given speed.
3. Tends to increase dive beyond control.
4. Might cause critical condition during flap operation.
5. Increases difficulty in getting tail down during landing.
6. Results in dangerous condition if tail structure is damaged or surface is shot away.

CG TOO FAR AFT



1. Creates unstable condition.
2. Increases stall tendency.
3. Definitely limits low power; might affect long-range optimum speed adversely.
4. Decreases speed.
5. Decreases range.
6. Increases pilot strain in instrument flying.
7. Results in a dangerous condition if tail structure is damaged or surface is shot away.



PRINCIPLES OF BALANCE

The theory of aircraft weight and balance is simple. It is that of the old familiar steelyard scale which is in equilibrium or balance when it rests on the fulcrum in a level position. It is apparent that the influence of weight is directly dependent on its distance from the fulcrum and that the weight must be distributed so that the turning effect is the same on one side of the fulcrum as on the other. A heavy weight near the fulcrum has the same effect as a lighter weight farther out on the bar. The distance of any object from the fulcrum is called its **arm.** This distance, or arm, multiplied by the weight of the object is its turning effect, or **moment,** exerted about the fulcrum.

Similarly, an airplane is balanced when it remains level if suspended at a certain definite point or ideal center of gravity (CG) location. Unlike a steelyard, it is not necessary that an airplane balance so that it is perfectly level, but it must be reasonably close to it. This allowable variation is called the CG range; the exact location, which is always near the forward part of the wing, is specified for each airplane model. Obtaining this balance is simply a matter of placing loads so that the average arm of the loaded airplane falls within this allowable CG range. Heavy loads near the wing location can be balanced by much lighter loads at the nose or tail of the airplane. The moments determine this exactly.

In practice, it has been found desirable to measure all distances from an arbitrary reference datum line at or near the nose of the airplane. By measuring arms in the same direction all moments become positive, thus eliminating possible errors in adding plus and minus moments that result from a reference datum line located within the limits of the airplane.

When the total moment about this reference datum line is divided by the total weight, the resulting arm is the distance to the center of balance, or center of gravity, from the reference datum line. This would be the location of the fulcrum as illustrated on the balanced steelyard scale. If the CG falls within the CG limits, expressed as forward limit and aft limit, the loading is satisfactory. If not, the load must be shifted until the CG does fall within the limits.

For flight, since the wing supports the airplane's weight, it is obvious that the CG must remain within safe allowable limits; otherwise, the tail surfaces could not properly control the path of flight. Limits are usually expressed as a

percentage of the mean aerodynamic chord of the wing (% MAC). However, for weight and balance purposes, and in this manual, the limits are given in inches from the reference datum line.

To obtain the gross weight and the CG location of the loaded airplane, it is necessary first to know the basic weight and the CG location of the airplane. This may be found by weighing the airplane. This weighing should be done with the airplane in its basic condition; that is, with fixed normal equipment which is actually present in the airplane, less fuel.

When the weight, arm, and moment of the basic airplane are known, it is not difficult to compute the effect of fuel, crew, cargo, armament, and expendable weight as they are added. This is done by adding all the moments of these additional items to the total moment found by weighing the airplane and dividing by the sum of the basic weight and the weight of these additional items. This gives the CG for the loaded airplane. This calculation can be performed by arithmetic, with loading graphs, or with a balance computer.

LOADING GRAPHS

Loading graphs and detailed instructions for their use are included in Section 7 of AN 01B-40 **(Weight and Balance Data)** a copy of which must be kept in the data case of the airplane at all times. These loading graphs provide an easy means of determining the loaded CG position of the airplane. They are intended for use when the balance computer is not available.

BALANCE COMPUTERS

To simplify the work of determining the loaded CG of the airplane, a balance computer is provided for each B-17 airplane and certain other types of aircraft, such as transports and patrol bombers, which may be easily unbalanced by improper loading and which carry such a large number of variable load items that calculation of their loaded CG by arithmetic or with the aid of loading graphs might be a somewhat lengthy and tedious process. There have been several types of computers used for this purpose. However, the load adjuster has been adopted as the standard computer for both the Army and the Navy. Instructions for using the load adjuster are included in Appendix I of AN 01B-40.

Definitions

The following definitions will serve as standardized terminology for all data in the practical application of this system. It is important to know them thoroughly.

Weight—The weight is 16 ounces per pound, avoirdupois weight. All weights are to be calculated to the nearest whole pound.

Basic Weight—The weight of the airplane, including all equipment that has a fixed location and is actually present in the airplane; that is, air frame; power plants and accessories; trapped fuel and oil; full hydraulic, cooling and anti-icing fluid systems and reservoirs; armor plate, ordnance (less ammunition and bombs); chemical, navigation, oxygen, pyrotechnics, and radio equipment. It never included items commonly referred to as disposable.

Note: The basic weight of an airplane varies with modifications and changes in the fixed equipment. This is not to be confused with empty weight, which is a dry weight with certain contract equipment only. The term basic weight, when qualified with a word indicating the type of mission, such as "basic weight for combat, for ferry, for transport, etc.," may be used with directives stating what the equipment shall be for these missions; for example, extra fuel tanks and various items of equipment installed for long-range ferry flights but not normally carried on combat missions which

will be in "Basic Weight for Ferry" but not in "Basic Weight for Combat."

Gross Weight—The total weight of an airplane and its contents.

Reference Datum Line—An imaginary vertical line at or near the nose of the airplane. Its location is chosen by the manufacturer as a standard line from which all horizontal distances are measured for balance purposes. Diagrams of each airplane show this reference line as zero.

Arm—For balance purposes, arm is the horizontal distance in inches from the reference datum line to the CG of the item.

Moment—The weight of an item multiplied by its arm.

Average Arm—Average arm or location is obtained by adding the weights and the moments of a number of items and dividing the total moment by the total weight.

Basic Moment—The sum of the moments of all items making up the basic weight. When using data from an actual weighing of an airplane, the basic moment is the sum of the moments around the reference datum line. For simplicity, it is permissible to divide the moment by a constant so as to reduce the number of digits. If this is done, the same constant must be used consistently for all computations, and must be indicated in the moment column on charts A, B, and C in Form F.

Center of Gravity—The point about which an airplane would balance if suspended. Its distance from the reference datum line is found by dividing the total moments by the gross weight of the airplane.

CG Limits—The range of movement which the CG can have without making the airplane unsafe to fly. It is determined by actual test flights. The CG of the loaded airplane must be within these limits at takeoff, in the air and on landing. In some special cases a landing limit is specified. On loading graphs the CG limits are indicated by CG limit lines. In all cases, the CG condition should be checked for landing without fuel and bombs.

Loading Range—The safe CG location under any load condition. It is shown on the balance computer as the white section labeled "Loading Range."

Tare—Weight of equipment necessary for weighing the airplane (chocks, blocks, slings, jacks, etc.) which is included in the scale readings but is not part of the basic weight.

Balance Computer Index—A number representing the amount which, when considered in conjunction with the weight, gives the CG position.

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